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THE HOUSE I LIVE IN.

Frame of the House I live in.

THE

HOUSE I LIVE IN;

OR

THE HUMAN BODY.

FOR THE USE OF FAMILIES AND SCHOOLS.

BY WM. A. ALCOTT,

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PREFACE.

The study of the human frame has usually been confined to the members of the medical profession. But wherefore? Why should not a subject which so nearly concerns us all, engage the attention of others as well as surgeons and physicians? Do we not carry about with us, through life, a machine so ingeniously constructed, that in view of it, even an inspired writer exclaimed, "I am fearfully and wonderfully made?"

Our minds, moreover, are the tenants of bodies so constructed as to be continually liable to waste, as well as to become disordered; and yet we are neither taught the way to keep them in order nor to prevent them from premature decay. These bodies act also upon our minds in a wonderful manner; for if anything in the body is wrong, it affects either our thoughts or our feelings, or both.

To keep the mind and heart right, therefore, we should know how to keep the body right.

Who understands this? What persons except medical men, as I said before, ever study their bodies? Is it not strange that knowledge of such vast importance should have been so long overlooked, and practically disregarded?

There are reasons, however, for all this neglect. Many connect with the thoughts of studying the human frame, the idea of skeletons, dead bodies, knives, dissections, disinterments, and violent deaths. No wonder the mind should revolt at so horrible a picture! No wonder that Anatomy and Physiology—for these are the hard names given to the study of the body and the laws of the body—should be neglected and despised, if these things are inseparable from it!

But they are not so. Both anatomy and physiology may be studied with advantage, without any connection with either. Much may be learned with the aid of nothing but a book and a few good engravings; and in fact without either of these. The body itself may be studied; that is always at hand. And if dissections are even made, portions of birds or quadrupeds may be obtained, which will partly answer the purpose. The heart, for example, of most of the common domestic animals, nearly resembles the heart of man, and would answer every purpose. All good citizens disapprove of every form of

disrespect for the bodies of the dead; and, above all, the barbarous practice of robbing graves.

Still this subject must be studied. Man, as has just been observed, has a body as well as a mind. A system of education which overlooks either, is essentially defective.

It was in this view, that the author commenced a series of essays on anatomy and physiology, in the first volume of the Juvenile Rambler. They were continued into Vol. 2, of the same periodical, and also into Vols. 2, 3 and 4 of Parley's Magazine. Many of them were written under the title of the "House I live in." The favorable reception they met with, and the solicitations of parents and teachers, together with an increasing conviction of the absolute necessity of something of the kind, have induced him to go farther, and prepare a work for families and schools.

But he wishes it to be distinctly understood, that he does not intend this as a substitute for any known work. The information which it gives, in anatomy and physiology, would, indeed, be of great value, without the study of other authors. But it is chiefly intended to introduce the young to such works as Smith's "Class Book of Anatomy," and Comstock's "Outlines of Physiology;" and if its adoption in part as

a reading book, and in part as a class book, in our schools, should smooth or pave the way to the use of those more complete works, the writer would not regret its publication.

He looks forward to the period as not very distant, whan a knowledge of the physical nature of man will be as generally taught to every individual of the whole race as arithmetic and geography now are; and will be as universally found in our schools. And he cannot but fondly hope to remove a little of the repugnance which many feel to this study, by the peculiar manner in which he has here presented it.

The general plan of the work is something more than mere theory. It has been tested by experiment, both in school and elsewhere; and with the most complete success.

There is one more hope that the author indulges, in the publication of this volume. It is, that it will have a good tendency on morals. Still more than all this. Besides having the favorable tendency which physiology must have on human happiness generally, the writer believes that no branch of natural science is more likely to induce us to look "through Nature up to Nature's God."

Boston, January, 1837.

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INTRODUCTION.

Before describing "the house I live in," it will be necessary to give a short account of other houses.

Huts, or Wigwams.

Among what we call savage nations, buildings are very simple in their construction, and rude in their appearance. They are often nothing

more than *huts* formed of the trunks of trees driven into the ground, and fastened together at the top. The branches and leaves of trees are then interwoven. Afterwards they are covered with bark, and some of the holes are perhaps filled up with mud or clay. Such were the miserable huts or wigwams of the North American Indians.

From a very early period in the history of our world, down to the present time, the people of all climates have felt the need of houses to live in, of some kind or other. In hot climates they serve as a shelter from the scorching rays of the sun, or the drenching rains which fall at certain seasons; or as a defence against wild beasts and reptiles. In cold countries, they help to prevent us from freezing, amid the frost and snow.

Many brute animals, as you know, build themselves houses. The beaver, the muskrat, the bee, and the ant, are examples. But there is one thing to be observed here—which is, that neither the beaver nor any other animal but man, builds its house one jot better now, than it did 5000 years ago; and if the world should last 5000 years longer, these animals will, undoubtedly, continue to build just in the same way.

That is to say, they make no improvement. But man has been constantly altering his mode of building, and, as we think, making improvements.

ANOTHER SORT OF HUTS.

One kind of dwelling, in early use, was in the shape of a *dome*. The frame was formed of long sticks, which would bend easily. These were sharpened at both ends, and then bent and driven into the ground. Next, these frames were thatched (that is, their roof covered) with straw. After this they were plastered inside and outside, with clay or earth, which soon became dry and hard. A place was left for a door or entrance, but not more than two or three feet

high, so that on entering them they had to creep on all fours!—A hole was also left at the top, to let in the light and let out the smoke.

The Caffres and other nations in South Africa live in such habitations, even now. Large villages, called *kraals*, are made up of them; and the king's palace is nothing more than one of these oven-like houses, a little larger than the rest; situated perhaps in the midst of a large yard, and surrounded by a thick row of rough wooden posts.

TENTS.

Another kind of habitations early used was *tents*. They were at first made of skins; afterwards of felt, and various kinds of cloth.

To build a tent, they first set poles very firmly in the ground, then spread on the covering and fastened it to them. The edges of the covering are fixed to the ground by pegs, or in some other similar way. The patriarchs mentioned in the Old Testament dwelt in tents. As their wealth consisted chiefly of cattle, they could thus move their houses from place to place, to new pastures, very conveniently. The Tartars and Bedouin Arabs still spread their tents in the deserts, and some of them are large and convenient, and very richly ornamented.

Account of Framed Houses.

I cannot tell exactly at what period men first learned to cut the trunks of trees into a

square form, and frame them together into houses; but you see that these framed houses were at first rather rude in their appearance. It was not long, however, before they learned to build them more elegantly; and now for many hundred years, but very little improvement has been made in the style of wooden buildings. But instead of wood, many buildings, especially in cities, are now made of brick and stone, which you know are much more durable than wood. This is particularly true of *stone*, which, it is well known, will last several hundred years.

I observed that there had been but very little improvement made in the style of building for many hundred years; but I meant in regard to elegance. People are learning, every year, how to construct houses so as to make them more *convenient* for those who occupy them; as well as more easily and cheaply *warmed*, *ventilated*, &c. The *ventilation* or *airing* of buildings, to purify them and make them more healthy, was once scarcely thought of. And as for fuel, which, so long as a country was new, many were glad to burn as fast as they could, in order to get it out of the way, they are now

contriving every ingenious method they possibly can to save it.

Frame of a Modern House.

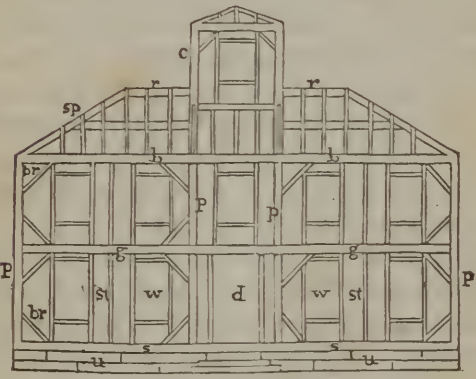
So many houses are built of brick and stone that perhaps some of my young city readers will scarcely know what a wooden frame means. At any rate, they will not know the names of the pieces of timber of which it is composed, as children in country towns usually do. I have therefore thought it would be best to present the picture of a wooden house frame, which I have employed an eminent artist to draw. It will be very necessary for the reader to study it a little while; for I shall speak of its sills, posts, girts, cupola, &c., presently, and I wish to be understood.

When they build a wooden house, they first lay a row of stones for underpinning. Sometimes they use other things instead of stones for this purpose; but not often. They lay these stones in a square, exactly where they mean to have the outside walls of the house. Having taken care to make it level, that is, just as high in one place as another, they

next lay on four long square sticks of timber, and join them together at the corners. These they call *sills*. If a house were to be exactly square—that is, just as long as it is wide—and you were to stand up in the air, over the sills, after they were laid upon the underpinning and framed together, they would look a little like the following figure.

When they have placed the sills, and put other pieces of timber across the inside of them,

then they set up other upright sticks upon them, and frame them into the sills at the bottom, and fasten them together with beams, studs, braces, &c., in such a manner that they cannot fall down; and this they call the *frame*.



Here is a view of the front or fore side of the frame of a wooden dwelling house. The engraver has marked it with letters, so that I can describe it to you without difficulty. As you look upon the front part of it, you can of course see only one of the sills.

That which looks checkered at the bottom is the underpinning. It is marked *u*, *u*. On it lies the front sill of the house, *s*, *s*. Four large upright pieces of timber standing on it are called posts, *p*, *p*, *p*, *p*. The cross piece, *b*, *b*, which unites them, is a beam. The other cross pieces, half way from the beam to the sill, are called girts, *g*, *g*. Studs, marked *st*, are small upright sticks framed into the cross pieces. Along the top of the house is the ridge, or ridge-pole, *r*, into which are framed sloping or oblique pieces, to support the roof. These are called rafters, or spars, *sp*. On the top of the house, at *c*, is the frame of the cupola. The place for a door, is marked *d*, and the places for windows, *w*. The short slanting pieces, like those marked *br*—all those, I mean, which are between the sill and beam—are called braces. Their use is to strengthen the frame.

With this short description, I hope what I have to say in the following chapters will be fully understood.

THE HOUSE I LIVE IN.

CHAPTER I.

GENERAL REMARKS.

Size of the House. Its Age—Beauty—Cost —Rooms—Occupants—Furniture.

"THE house I live in" is a curious building; one of the most curious in the world. Not that it is the largest, or the oldest, or the most beautiful, or the most costly; or that it has the greatest number of rooms or occupants, or the most fashionable furniture. But it is one of the most wonderful buildings in the world, on account of the skill and wisdom of the great Master Workman who planned it. You cannot view it closely in any part of it, without being struck with the wisdom he must certainly have had, nor without desiring to become acquainted with him.

Size of the House.—I said it was not the largest building in the world. Very far indeed from that. The mosque of Omar, at Jerusalem, which, according to travellers, is 1489 feet (more than a quarter of a mile) long, and 995 feet wide, covering forty-one acres, is of course millions of times as large. The palace and church of the Escurial in Madrid, in Spain, is nearly a mile in circumference. The great tobacco factory at Seville, in Spain, covers about seventeen acres, and is of course millions of times as large as my house is. So are also St. Peter's Church at Rome, and St. Paul's in London; the latter of which covers six acres. Even the City Hall in New York, which is only 216 feet long and 105 broad, is many thousand times as large as the house I live in. In truth, the latter is only a foot or two in extent in any direction. Its height is almost as diminutive as its extent; for though it has two stories, with a cupola, it scarcely towers beyond the height of six feet.

Its age.—It is not the oldest building in the world. A traveller assures me that he once saw a house in Nantes, in France, in

which Julius Cæsar slept at the time of his passing through France to invade Great Britain; which you know is almost two thousand years ago. Buildings of brick and stone several hundred years old are very common in Europe. They are, of course, less so here, because it is little more than 200 years since our ancestors came over here, and began to drive away the savages and erect dwellings. Yet even here you will occasionally find a house nearly 200 years old. There are some *wooden* houses, both in Boston and its vicinity, which are not far from 150 years old. But the dwelling I am going to tell you about has not yet stood half a century.

Its Beauty.—The house I live in is not the most beautiful. It is not indeed without beauty; but how would it compare with the elegant temple of Solomon, in the days of its glory?—or with the Arcade of Providence, the Massachusetts Hospital in Boston, or the Capitol at Washington? Some indeed undertake to say that it is a great deal more beautiful than any of these! On this point I leave you to form

your own opinion, after I have told you more about it.

Its Expense.—Nor is it the most costly. Many a building has cost its millions of dollars. The Capitol at Washington cost two millions, and even the City Hall in New York half a million. The Seville tobacco factory, in Spain, cost six millions. Some European palaces, or residences of kings, probably cost a dozen or twenty millions. The house I live in meanwhile, did not probably cost one thousand. Indeed it scarcely cost me anything; for it was found ready to my hand. The expense of the human frame would be much more than it is, were we not more anxious to bring it to maturity as quickly as possible, than to have it strong and firm. In general, the slower the growth of the body, the better.

Rooms.—Nor does it contain the greatest number of rooms that I have ever known in a building. It contains indeed a very large number for so small a place. Perhaps there may be a dozen, or fifteen, or twenty. Whereas the

Astor House in New York contains several hundred, many of them large and commodious; and the Tremont House in Boston, one hundred and eighty. The Palace of the Escurial in Madrid has 1860 rooms.

Occupants.—As to the number of occupants, it will not compare at all with most buildings. Churches will contain a thousand people at a time—some of them more. Theatres will also accommodate their thousands of visitors. Public houses will even accommodate their hundreds of travellers, and some of our boarding establishments many hundreds of boarders. I have been shown a few boarding houses in our own manufacturing villages that contained—not *accommodated*, for they did not—three or four hundred boarders. In Paris, Vienna, Edinburg, St. Petersburg, and even in New York, fifty persons, and sometimes more, are occasionally crowded together into a single building. The Spanish tobacco factory, of which I have already spoken, employed 1500 to 2000 persons. But the house I am describing, like the huts of some of the ruder

tribes of New Holland, never accommodates but one person, and that is myself.

I have mentioned the rude huts of some tribes of the New Hollanders; but theirs will not compare very well with mine throughout. They are made of the bark of a single tree, bent in the middle, and placed with its two ends on the ground. When they have lived in a hut of this kind as long they please, they leave it; and if they go to a new place, build another; and the old one is taken possession of by any that choose. Whereas I always carry my house with me wherever I go.—You will interrupt me, perhaps, by saying that the snail, the tortoise, the oyster, and the lobster, do the same; and you are right.

The house I live in is good for nothing at all for any one but myself; and when I leave it, it will immediately go to decay. I would not exchange it, however, if I could. I like it—as the Icelander does his frozen country—better than any other.

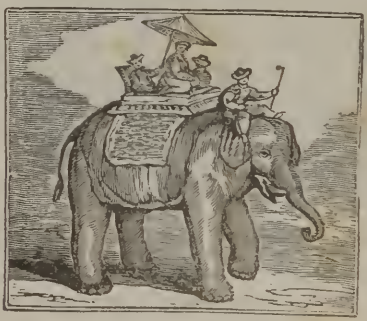
Furniture.—Lastly, I have already confessed that my furniture is not of the most fashionable kind. Of this the reader can

best judge for himself when he understands that it has been the same in kind for nearly forty years. The fashions you know, in general, are often changing like the moon; and what is in fashion now, will next year appear ancient. Can it be expected, then, that the furniture which was selected for the house I live in during the past century, will correspond with the fashions of the present?

In Siam, they build their houses on posts or pillars. This is because the country is low, and apt to be overflowed every year by the rivers; and to build on high posts is the only way to secure themselves against these floods. My house, as you will see hereafter, stands on

pillars, but they are made for motion; whereas you cannot move a Siamese house without spoiling it.

There is one thing which bears a slight resemblance to the house I live in. It is the house, or tower, sometimes, in the East Indies, placed on the back of the elephant. In these houses or towers the people travel—twenty or more of them at a time. In like manner, I carry about my house, from place to place, wherever I go. Here is a picture of the house on the back of an elephant, of which I have just spoken.



The house I live in, after all, is most remarkable for its convenience. Nothing could

possibly so well answer my purpose. I have already told you that it would be good for nothing for any other person. Your house, my young reader, may be as beautiful, as curious, as large, and even as commodious for you, as mine is for me; but it would never answer my purpose at all, even if I had it in my power to exchange with you.

In the progress of the following chapters, I shall give you many more particulars. I shall describe to you, in the best way I can, the FRAME, the COVERING, the APARTMENTS, the FURNITURE, and the EMPLOYMENTS of the house I live in; and shall give you, briefly, an account of the structure, uses and abuses of each. At first, I intended to insert a little dictionary or vocabulary of the hard words which occur, with their meanings; but I believe it is unnecessary; for there are few, if any, whose meaning you will not know at once, either by their sense or the situation in which they are placed.

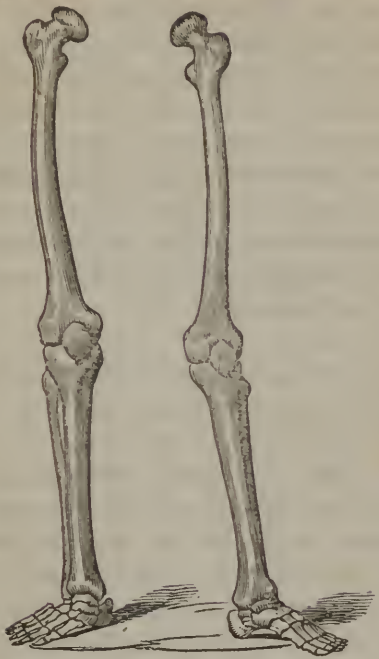
CHAPTER II.

FRAME-WORK OF THE HOUSE.

The Thigh Bone. The Leg. The Knee Pan. The Foot. The Arch of the Foot. Proof of Contrivance. The Ankle.

THE picture which you see on the next page will at once unravel all the mysteries of the last chapter. You will see that the house I live in is my body—the present residence of my immortal spirit. You will also discover that the frame-work consists of bones.

THE PILLARS.—The pillars are the bones of the lower extremities. Standing by themselves, as they do in the engraving, you will be apt to think they are not well proportioned; but when you come to see them in connection with the rest of the building, they will appear very differently.



I spoke of the lower extremities of the human frame. These are commonly reckoned in three divisions; the thigh, the leg, and the foot. Besides these, there is the knee pan

or patella. Each thigh has one bone, each leg two, and each foot twenty-six.

Besides these—fifty-eight in the whole in both legs—and the two patellas, there are in some people, at the largest joint of the great toe, one or two small bones, having a slight resemblance to the knee pan, or patella. They are called sesamoid bones; because they have been supposed to resemble the seeds of the sesamum, a wild eastern plant.

THE THIGH BONE.—The bone of the thigh is called the *femur*. It is the longest bone in the whole human frame. At its upper end, where it is connected with the hip bone, is a round knob or head. This head fits into a corresponding hollow or cavity of that bone, and is fastened there in a way which will be described in another place. These round heads do not appear quite round enough in the engraving at the head of this chapter. The cut at the part of the book just referred to represents this important part of the human frame much more correctly.

THE LEG.—The lower end of the femur joins with or rather rests upon the large bone of the leg. The leg below the knee consists of *two* bones. The *tibia* (so called because it resembles a tube or pipe, or as some have imagined, a hautboy) is much the largest. The other is called the *fibula*. They are so placed that the fibula is on the outside. Where the tibia and the femur meet, they form what is called a *hinge joint*, which means a joint that will only allow of motion backwards and forwards in one direction, like a door on its hinges. But more about this in another place.

THE KNEE PAN.—On the fore part of each lower extremity, where the femur meets the tibia and fibula, to form the knee joint, the patella or knee pan is placed. This is a round flat bone, not joined to the other bones, but lying very closely on them, and kept in its place by what are called tendons. You may see a little how this bone looks in the last engraving; but I here present you with a picture of it, on a larger scale.

Although this bone might seem at first view almost useless, yet it serves many important purposes; and there is scarcely a bone in the body but might be spared as well if not better than this.

THE FOOT.—The bones of the foot have a general resemblance to the bones of the hand, which I shall describe fully in another place. But they also differ from those of the hand in several important particulars.

The foot is composed of twenty-six little bones, strongly fastened together by gristle, or ligaments. These ligaments yield, when we bear upon the foot, just enough to have it conform to the surfaces on which we tread. If the foot consisted of one solid bone, it would not yield or spring at all; and it would be liable to be broken when we jump or fall on our feet. Think how clumsy a wooden foot would be! And one of solid bone would be nearly the same thing.

Arch of the Foot.—The *arching* of the foot is a singular contrivance. It is really much like an arched bridge and its two abutments. I will explain.

In the above engraving, the foot is not placed flat down upon the ground, but in the position which it has when we walk, and are just setting it down. Then, as may be seen by the two lines drawn, it descends in a semicircle from the point of the heel.

You may easily perceive how awkwardly we should feel if we were obliged to walk with a *flat* foot, by lashing a strip of wood to the bottom of the foot. It is quite evident there would be no *spring* when we tread on it. We could hardly walk, run, leap or swim.

Another thing. The heel is not exactly under the leg, but runs back like a spur, and is

fastened to the main body of the foot by a very firm but springy (elastic) joint. On this account, when we walk, (the heel being thus formed like a spur, and having a great deal of elasticity,) we put it down first, and the whole weight of the body does not come down with a jolt, but more gently.

Its Contrivance.—Taken altogether, the foot is a most admirable contrivance. It is, indeed, arched *both* ways; from the toes to the heel, and from side to side. It will help you to get a clearer idea of this arched structure, to step into the water with your bare foot, and then step immediately upon a dry floor, and see what sort of a track it will make. You see only a small spot for the heel, and several such small spots for the toes. Little, if any, of the middle part of the foot touches the floor at all. There is, however, a difference in feet. Some persons have much flatter feet than others.

I have said that the human foot is a most admirable contrivance; and it is so. There is nothing like it to be found among the other animals, though we find wonders even there.

When we examine the foot of the camel, the elephant, the horse, the dog, the cat or the bird, we are struck with the wisdom of the Creator, in adapting their feet in so remarkable a manner to the sort of life they are destined to lead. The foot of the camel is so made, that it does not sink deeply into the sand on which it travels. The horse could not travel much in the deep sands of Arabia. His foot is more elastic, and made for firmer ground. It is, indeed, so very elastic, that those who *shoe* the horse find it necessary to make the shoe as narrow around the edge as possible, so that the iron may not press upon the inside of the foot;—I mean, upon the softer and more elastic part, inside of the hoof.

I have not room to go into farther particulars about the foot; but I should like to do it. Children are very fond of these studies, though some people think otherwise. They are better philosophers, too, than we usually allow them to be; and if these subjects were only presented in plain language, and the instructor would take time enough, they would understand the philosophy of the foot better than many of us, their seniors, suppose. People

are not apt to give young children time enough to get clear and well-fixed ideas of things. Both teachers and parents are quite too apt to hurry over things rapidly, as if they thought the young would be wise in proportion to the number of books studied, or rather *run* over.

The Ankle.—Between the lower ends of the tibia and fibula, and the bones of the foot, are seven short bones, not unlike those of the wrist in shape, but rather larger. Of these you will get a tolerable idea, when I come to describe the bones of the upper extremities.

CHAPTER III.

MATERIAL OF THE FRAME.

Structure of Bones. Shape of the Bones. Particular Description. Growth of Bone. Vessels of the Bones.

You have already seen that the frame-work of "the house I live in" consists chiefly of bone. I think, therefore, that before we go any farther, I ought to tell you how bones are constructed, and of what substances they are made.

Structure of Bone.—Sticks of timber are evidently full of little holes; for if you take a piece of wood, of several kinds which I could mention, and put your mouth at one end of it, and blow hard, you can force air through it. This shows that there are little holes in it, running lengthwise, all the way through. If

you could blow hard enough, you might blow through any kind of wood whatever. The philosopher and chemist will force water and even quicksilver through the pores of almost any sort of wood. Surely then *air* can go through. At all events, whether we can get the air through or not, there are indeed holes through it.

But you cannot blow through any of the timbers of the house I live in. This shows that the internal structure of bone is very different from that of wood. I will endeavor to show you wherein it is different.

SHAPE OF BONES.—Bones are of three kinds;—*long* bones, *broad* or *flat* bones, and *round* bones. The long bones have a hollow through them containing marrow or pith; but the other two sorts of bones have no such hollow. They have, however, a great many little holes or cells in the inside. Some of them look, on breaking them, almost like sponge or honey-comb. Some of the long bones, besides being hollow, are also spongy. They are largest and most spongy at the ends, and smaller and more firm at the middle.

All the bones in the body are very hard on the outside. Perhaps the teeth are most so. The inside of the teeth is not much harder than other bones; but the outside is coated with a substance called *enamel*, which is very hard indeed.

Particular Description.—You have already been told that the long round bones, such as the humerus and the femur, are hollow, and have marrow in them. This marrow nearly or quite fills up the hollow.* There is a very thin membrane that lines the hollow, and also runs among the marrow. The same sort of membrane lines also the little cells in the spongy bones. These cells have a small quantity of liquid in them. None of them appear to be entirely empty.

Most of the bones are pierced through their outside with one or more holes of considerable size, through each of which goes an artery to convey blood to the bones; and a vein comes

* This is true of the bones of most other animals besides man. Some of the bones of birds, however, are said to be entirely hollow and empty.

out the same way, to bring it back. You may wonder that I should talk about blood in the bones. But there *is* blood in them, though not a great deal. This blood, and the nerves and membranes of the bones, together with the marrow and liquid matter which they contain, amount to many pounds; for after the bones of any animal have been dried several years in the air, they become almost twice as light as before. The bones, when perfectly dry, weigh from eight to twelve pounds.

When they appear entirely dry, if you burn them in a hot fire for a long time, you will lessen their weight a great deal more; I believe about one half. What burns out, in these cases, is animal substance—principally *gelatine*. The half which remains is mostly carbonate of lime, or chalk. So that a person carries about with him, every day, from four to six pounds of lime; perhaps more.

The great purpose which the Creator doubtless had in view, in giving us such a framework of strong bones was, that it might support the soft and fleshy parts. Suppose, now, that there were no bones; and that the whole body was a mass of flesh. Would not the legs bend

about, and finally be crushed down, under the great weight of the body? Most certainly they would.

But there are several other important uses of bones, which might be mentioned. Some of them you would not understand very well, however, till you know more about muscles and tendons. I will, therefore, omit them.

Growth of Bone.—We are not born with the bones as hard as they are after we begin to walk and run about. At first, many of them are very soft; and a large number are in several pieces, with *cartilage* or gristle between them. After a few years, they grow firmly together. The bones of the head, in particular, are at first separate; and, without doing any mischief to the soft brain within, will move a little. But after we become older, and the whole skull becomes firm, it would require a very considerable force to move them; and the consequences of moving them would be dangerous.

There is undoubtedly *life*, as it is often called, (though we hardly know what life is,) in bones; but while we are well, there is not

much feeling in them; and when the surgeon amputates or saws off a limb, the sawing of the bone does not cause much pain, till he comes to the marrow.

Vessels in Bones.—There are also many blood-vessels and nerves running about in small holes in the bones; and wherever there are nerves, there is life. But if this does not show that there is life in the bones, there is another thing which I think will satisfy you of the fact.

In some diseases of the bones, they are as sore and painful as the flesh can be. Could you make a piece of dry wood, or even a dry bone, sore or painful? Certainly not. Then must there not be life in the bones of the living person?

We are now prepared, I think, to proceed with our studies on the frame-work of the house.

CHAPTER IV.

SILLS OF THE HOUSE.

Situation of the Hip Bones. Structure. The Hip Joint. An Abuse.

You well know, I suppose, that after the foundation of a common building—say a dwelling house—is well prepared and made level, they lay on large sticks of timber, called sills. On these sills they place the *body* or principal portion of the building, and by means of joints fasten it at the corners, as well as at other places.

Situation of the Hip Bones.—The sills of the house I live in consist of two large irregular bones, placed at the top of what I have called, for convenience' sake, the pillars. These two large bones are very firm and strong. You will find so much difficulty in

understanding my explanations of their shape without it, that I will show you a picture of them.

These bones are called in books the *ossa innominata*. *Os* is a Latin word for bone; and *ossa* is its plural, meaning more bones than one. *Innominata* means *without a name*, or nameless; but the very word *innominata* makes a tolerable name, though rather long. So if a very young child, found in the streets, whom nobody knew, should be called Peter Nameless, that word *nameless* would answer all purposes.

Structure.—I have said that the ossa innominata were very firm and strong. They are so in grown persons—but in a child they are less so, and are in three pieces, each of which has a different name. They are joined together by a firm gristle or cartilage. Behind,

however, is a strong wedge-like bone, between them. Between this last bone, called the *sacrum*, and each of the ossa innominata, there is also a very strong gristle; but it is not so thick or strong as the one I have just mentioned. The ossa innominata and sacrum make a kind of cup, or deep bowl—open at the bottom, it is true, but still bowl-like in its shape. This bowl is called the *pelvis*.

Hip Joint.—The manner of fastening the thigh bone, or femur, to the hollow of the innominata, is very remarkable. I shall give a particular account of it, with an engraving, farther along in the book; so that a few words must answer, for the present.

The hollow, where the femur is fastened, is shaped like the inside of an egg shell, with the small end broken off. The round end of the femur is fastened in this deep cavity, by a very large and strong cord. The shoulder is often dislocated, or slipped out of its place; but this hollow is so deep, and the cord so strong, that nothing but very great violence will break the cord, or slip the femur out of its place.

An Abuse.—I have said that these two great bones are united by a very strong cartilage. This is true; but it is also true that while we are young, and even after we are older, if we have lived temperately, this cartilage, which is very thick, will stretch or yield much more than you would at first suppose possible. It is of very great importance to everybody—though much more so to some than to others—to preserve the soft and yielding nature of these cartilages as long as possible. To do this, you must run about and play much while young; not with violence, but like the lamb; you must labor moderately every day, as you grow older; you must rise with the lark, and go to bed almost as early as the fowls; you must breathe pure air; your drink must be water, and your food must be of the plainest and purest kinds, and not in excessive quantity—and must be well chewed. Then may you hope to preserve your bones and cartilages in a good and healthy state till you are quite old. But some of these things will be adverted to again in other chapters.

CHAPTER V.

BODY OF THE HOUSE.

Height. The Spine. Each Vertebra. General Description. The Ribs. The Breast Bone. The Collar Bone. The Shoulder-Blade.

HEIGHT.—Houses consist of one or more stories, according to the length of the posts. Each story, as you know, forms a separate row or tier of rooms. The best houses are those with fewest stories.

But most people prefer, if they are able, to have at least two stories—some three. In cities, where land is very costly, they sometimes have them four, five, seven, ten and even eleven stories high. Four stories in our large cities is very common. A house ten stories high, accommodating ten rows or tiers of people, one above another, must be a curious sight. The

house in which I live has only two stories, besides a cupola.

THE SPINE.—The principal post—-the spine—runs through both stories, and is of a singular construction. We usually call it the *back-bone*. Here is a representation of it.

The spine is composed of no less than twenty-four separate pieces; each of which is

called a *vertebra*. The plural of vertebra is *vertebræ*.

The seven lower vertebræ are very large and strong. These parts of the frame are the only supporters of the first or lower story. The twelve next above them, belonging to the second story, are somewhat smaller. The seven which belong to the neck are smaller still. Their size, in general, decreases—not suddenly, but gradually—from the bottom upwards. They are placed one above another, somewhat like tea-cups or saucers inverted and piled up.

The spine or back-bone is not only curious in its shape and structure, but of the utmost importance in the human frame. It has been sometimes said, that "if one member," in any part of the body, "suffer, all the members suffer with it." This is especially true of the spine.

Each Vertebra.—Each vertebra has a hole of considerable size in the middle of it. See *b* in the engraving below. What I show you, is the upper surface of one of the verte-

bræ. It is as if those above it were taken off, and you viewed it while standing over it.

When the twenty-four vertebræ are placed one above another, that is, are in their natural position, they contain a long hollow. This hollow is filled with a soft substance, very much resembling the marrow of other bones. It seems like an arm or branch of the brain; for there is an open passage from the bottom of the cranium, or brain-pan, into the hollow of the spine.

General Description.—When the vertebræ are put together, that is, laid upon each other, there are notches between each two bones at the sides, so exactly matched together as to form a hole. Thus there are as many

holes in each side of the spine as there are vertebræ. Through these holes large branches of the marrow of the spine pass off, like the branches of a tree, to all parts of the body. These branches are called nerves. At first, they are pretty large; but they divide and subdivide, as they proceed towards the extremities of the frame, till they become very small. Their number, in all the soft parts of the body, particularly in the skin, is very great. I do not know that they could be counted.

Those things which look like three arms, by interlocking with the bones above and below them, serve as braces to the whole spine. At the sides are parts of the ribs (*c c.*) These show where the spine and ribs come together.

Between these bones, where the body of each (*a*) rests upon the other, is a tough substance or gristle, very yielding or elastic, almost like India rubber. This keeps the bones from wearing out too fast when they move, and yet it allows of their moving pretty freely.

The spine is, really, one of the most curious things in nature. Why, rope-dancers and tumblers will bend their heads back till they almost touch their feet, and bring this straight pile of

bones nearly into the shape of an ox-bow. Why does it not produce mischief in some way?

The gristle or cartilage between the vertebræ is very thick and strong, but at the same time very yielding, like India rubber; and it is so constructed and placed, as will best allow the spine to bend about in all the various ways which even tumblers and rope-dancers could wish.

It is so elastic or springy, and also so readily compressed, that people who stand or walk much, are really a little shorter at night than they are in the morning. Rest gives the elastic cartilages time and opportunity to spring back again into their place, while we sleep, so that by the next morning we are as tall as ever.

I ought, however, to say—for it is a fact—that old people settle down a little, and are not so tall as in middle age; which is partly owing to these cartilages yielding and yielding till they become thinner.

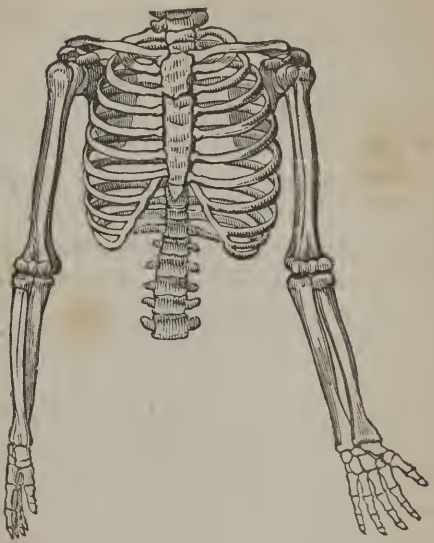
If the soft marrow of the spine, (which runs down from the brain,) should happen to be bruised or injured, there would be an end of all

motion, at least of the lower limbs. If the spine gets broken, it cannot be mended, and the sufferer will never wholly recover. How happy, then, that it is so contrived, as rarely to be broken, or dislocated!

The other and shorter posts of the "house" will be mentioned presently.

We are ready, now, to study the frame of the upper or second story of the building. It consists of a much greater number and variety of parts than the frame of the first story.

THE RIBS.—The ribs may be compared to the girts of a building; though they look more like the hoops of a cask than like girts. There are twelve of them on each side. Each of them is connected, by one of its ends, to the large post, or spine; and, by the other, to a shorter post—the breast bone. Only seven, however, are joined closely to the breast bone itself. The other five go a part of the way across; the rest of the way they are formed of gristle or cartilage. The former are sometimes called the true ribs; the latter, the false ones. Here is a view of this part of the frame.



The length of the ribs increases from the first or upper one, till you come to the seventh, which is the longest. From the seventh to the twelfth, they grow shorter again, and the cartilages, of course, become longer in the same proportion. The twelfth rib is very short.

The number of ribs is almost always twelve; but sometimes there are only eleven, and at others, thirteen. But instances of more or less

than twelve do not probably occur in one person in a thousand.

There is a notion prevailing in some parts of the world—I know not how it was first started—that *man* has one rib less on one side than on the other. They say that as Eve was formed of a rib taken from Adam's side, he and all his male posterity have one rib the less for it. I hardly need to say that this opinion is wholly unfounded.

Breast Bone.—I have just alluded to the breast bone. The name of this, in books, is the *sternum*. It has been usually considered as only *one* bone; but, like many others of the human frame, in infancy and youth it consists of several pieces (three in number) closely united by gristle or cartilage; but in advanced life, the whole usually becomes one solid bone. Long continued boiling, however, will separate almost any of the bones which are formed in this manner.

There are a few other parts of the frame of the second story which remain to be noticed, and which I will call the braces. They are four in number—two before, and two behind.

The braces here alluded to are,

1. *The Collar Bone.*—This forms a kind of brace between the shoulder and the breast bone, and so nearly resembles a rib, that a separate cut, to show its shape and position, seems unnecessary. You will see it in two or three of the engravings, running across from the shoulder to the breast bone or sternum.

2. *The Shoulder-Blade.*—This is a broad, flat bone, with ridges on it; and, at the fore part, is the hollow, or socket, in which the round head or ball of the humerus or arm-bone lies and moves. Here is a view of it behind.

CHAPTER VI.

BODY OF THE HOUSE—Continued.

The Arms. The Hand. Uses of the Hand.

Arms.—These are not posts, for, in their natural position, they support nothing. They are not braces, for they strengthen no part of the frame. They are properly *appendages*, but they are very convenient ones; and though they can be torn off without spoiling the building, their loss very much injures it. They seem to answer, in some good degree, the purposes of stairs, ladders, tackles, pulleys, and other machinery for raising things from the ground, and conveying them to the upper part of a building. These appendages—we may as well at once call them the arms and hands—however, answer a much better purpose than any of those.

The arm and hand, taken together, constitute a most wonderful apparatus for motion. The particular structure of the joints, as well as the peculiarities of the hand, must be reserved for another place; but it is necessary to say a little about the arm.

The bones of the arm have a slight resemblance to those of the leg. The upper part consists of only one bone. This is long and round, and is called the *humerus*. It is fastened above to the scapula. Below, at the elbow, it is connected to the two bones of the lower half of the arm, by a joint like a hinge, and by ligaments or straps, which go from near the end of the upper bone to the end of the others. The largest of the two latter bones is called the *ulna*, which is a Latin word for cubit, because the arm, below the elbow, is usually considered about a cubit in length. The smaller one is called the *radius*, or spoke, from its supposed resemblance to the spoke of a wheel.

The connection at the shoulder is such, that the arm can be moved in almost every conceivable direction. The elbow joint only ad-

mits of one sort of motion, viz., forward and backward, like a door on its hinges. But the connection of the radius, or smaller bone of the arm, with the ulna, or larger one, is such that it more than makes up for this deficiency. Then the wrist, consisting, as it does, of eight bones, all movable, and being so connected with the lower bones of the arm as to admit of very free motion, renders the arm one of the most useful contrivances in the world. It will perform as various and as rapid movements as the trunk of the elephant; and would probably, if it were not so common, excite as much surprise.

It was said that this whole member could be torn off without spoiling the building. Cheselden, an English anatomist, relates that a miller had the whole arm, shoulder-blade and all, torn off, and yet recovered. The great danger, in such cases, is from bleeding; but *torn* blood-vessels do not bleed so freely as *cut* ones.

THE HAND.—I wish to give you a few particulars about the hand. This extremity of the arm is by far the most curious part of it.

Indeed, I do not know that there is a greater curiosity in the whole world than this same human hand. Yet who thinks much about it?

The truth is, many of the best, as well as the most curious objects in the world, are neglected in the same manner. Think of the thousand uses of *water*. What living thing could exist without it? Yet do we think much of all this, and are we even thankful for so valuable a gift as water is?

The bones represented in the engraving are those of the left hand; and you look upon the top, or backside of it. The foot is also inserted here, but has been described in another place. See Chap. II.

The whole hand and wrist contain twenty-seven bones; nineteen in the former, and eight in the latter. The bones in the hand have a general resemblance, though some are much longer than others. The four longest, opposite figure 1, support the palm of the hand, and are joined at one end to the wrist bones, and at the other to the first joint of the fingers. They are called the *metacarpus*.

The bones of the wrist are called the *carpus*. They are situated between the ulna (5) and radius (6) on the one side, and the metacarpal bones and the first bone of the thumb on the other. They are wedged together, like the stones of a pavement, only not quite so firmly.

The first four bones of the fingers, opposite figure 2, are the longest. Those opposite 3 are shorter; the last, or those marked 4, are shorter still. The thumb has one bone less than the fingers. All the joints of the hand—

and there are fourteen, besides the wrist—are hinge joints, and the ends of the bones are made a little like door hinges. Of course they only bend in one direction. Where the fingers join to the metacarpal bones, there is much more freedom of motion than at the hinge-like finger joints. But the joint at the wrist admits of motion, very freely, in every direction.

When the bones of the hand are not quite so naked as they appear in the engraving, but are dressed up with muscles, tendons, membranes, nerves, arteries and veins, and covered with skin, nails, &c., in a manner which I cannot now fully describe, the whole presents a most beautiful appearance. Beautiful and useful as it is, however, and placed before our eyes from the time we see the light till we sleep in death, there are few things in the whole visible world, of which not only children, but adults, are so ignorant!

So important is the human hand, as a member of the system, that Dr. Bell's Bridgewater Treatise—a pretty large volume—is wholly devoted to a description of it. The reader will

pardon me if I make, in this place, a short extract from that admirable work.

"The difference in the length of the fingers serves a thousand purposes, adapting the hand and fingers, as in holding a rod, a switch, a sword, a hammer, a pen or pencil, engraving tool, &c., in all which a secure hold and freedom of motion are admirably combined. Nothing is more remarkable than the manner in which the delicate and moving apparatus of the palm and fingers is guarded. The power with which the hand grasps, as when a sailor lays hold to raise his body to the rigging, would be too great for the texture of mere tendons, nerves and vessels; they would be crushed, were not every part that bears the pressure defended with a cushion of fat, as elastic as that which we have described in the foot of the horse and the camel. To add to this, there is a muscle which runs across the palm of the hand, and supports the cushion on the inner edge. It is this muscle which, raising the inner edge of the palm, forms the drinking cup of Diogenes."

USES OF THE HAND.—Small as this member of the frame is, it is a part of the utmost consequence. Even if the house the soul lives in were a palace, or had cost as much as St. Peter's church at Rome, or the Pyramids of Egypt, it would be of very little use without it. And if all such houses in the world were without it, neither those houses, nor anything else, would long be worth much. The farmer could not sow his grain, or plant his corn, or weed or hoe it while growing, or collect it when ripe. Nor, if it were grown, could the miller grind it, or the baker make it into bread. Neither could we raise anything else to eat in its stead. We might get along a few years with what is already raised; but what then? The fruits and roots and nuts which grow without cultivation—I mean without our labor—would not last us and the thousands of beasts and birds which feed on them, very long.

Do you say that if we could get nothing else to eat, we should then have a good right to kill and eat animals? But we could not get them. How could we?

Besides all this, the tailor could not make us clothes, nor the hatter and milliner hats and bonnets, nor the shoemaker boots and shoes. When those which we have by us already made were worn out, we should be obliged to go naked, summer and winter, in all climates; for we could not get even the skins of animals.

Then again, we could not write to other parts of the country for help, even if there were any body to help us. Neither could the mariner seek a cargo of food in other countries; for he could not spread his sails, or hold the helm of his vessel. In short, we could do nothing long, to any purpose; but after gazing awhile upon each other's starving and emaciated frames, we should all lie together in one common tomb—and that tomb would be the surface of the earth, arched over with the blue canopy of the heavens; for nobody could be buried.

Some of you may think this representation of the sad case we should be in rather exaggerated. "We should *not* be such helpless creatures," you may perhaps say. "Why,

there is a story I have seen, about a French woman, who was destitute of this instrument and some others, and yet she could do a great many sorts of work, and even *write*, *draw* and *sew*." Yes, and the story was undoubtedly true. I have heard stories like it before. I have heard of a man, in the same condition, who could write with his *breast*. His pen was fastened to a girdle, and then he could dip it in the ink, and write very well with it.

But you should remember that these persons could not make the pens and pencils to write and draw with, or the needles to sew with. Nor could the man have placed the pen in his girdle. And there are a thousand other necessary things which they could not do. Now if everybody was like those persons, the whole world would perish in fifty years, if not long before.

The human tongue is spoken of by an inspired writer as being a "little member," yet boasting great things. So this small member of the frame which we are talking of is a "little" affair, but great things depend upon it.

It is a sort of connecting link, that, if used, serves to bind the human soul to the habitation it occupies, for a few years—seldom more than a hundred. Without it, or neglecting to use it, our lives, as *a race*, must soon terminate. "He that would not work, neither should he eat," is a divine law; and we could not work much without this little instrument.

CHAPTER VII.

THE CUPOLA.

The Cranium. The Teeth. Growth of the Teeth. Structure of the Teeth. Uses of the Teeth. Bones of the Ear. Bone of the Throat.

We come now to the cupola. The frame of this rests on the top of the great post. I have already told you that seven of the twenty-four pieces which go to make that post are situated above the second story of the building. Some of them you can just see in the pic-

ture ; but the others are omitted. You see, also, the places for the doors and windows.

I must stop here long enough to say that—unlike what is seen in almost all ordinary dwellings—the doors and windows of the house I live in are in the cupola : there is not one door in either the first or second story. The windows, and some of the doors, are placed in front—the rest of the doors at the sides. The doors and windows themselves, as you know, properly belong to the covering. They will therefore be described under that head.

I have called the mouth and ears and nostrils doors, to keep up the figure ; and also, because these are, in fact, the principal avenues to the human soul, except the eyes ; but these may, with the greatest propriety, be regarded as windows. All sound, smell, taste, &c. come to us through these passages, and the machinery or organs near and within them. Why then may they not properly be called doors ?

The Cranium.—At the beginning of this chapter, I showed you a picture of the bones of

the whole head. Now if the bones of the face and neck were taken quite away, and nothing left but the hollow brain-case, (*cranium*,) the appearance would be very different. Here is a front view of a skull from which the bones below have been thus removed.

You see, in front, the top of the cavity or socket for each of the two eyes; and on one side, the place where the ear should be in the living person. This brain-case is composed of eight bones, most of which are closely united by a rough edge, like that of a saw, the notches of which shut into each other as exactly as saw teeth would, and form what a tailor would call seams. These seams are by anatomists called *sutures*.

One of the most important bones of the skull, or brain-pan, is that which stretches

across the whole forehead, and is called the *os frontis*, or frontal bone. Another, across the backside of the head, and shaped thus, A, is the *os occipitis*. Its sharp top reaches to the crown of the head. Another piece, shaped a little like a clam shell, lies around each ear. It is the *os temporis*. There are, of course, two of these. On the top of the head, surrounded by those already described, are the two *parietal* bones. Surrounded by them all, in the bottom of the skull, is a large bone, the *os sphenoides*, and a small one, the *os ethmoides*.

Now, as I shall hereafter show you more fully, this whole space is filled up with brain. In an adult, the brain weighs from two and a half to three and a quarter pounds; or it measures one quart or nearly. In a few instances, it has been found somewhat larger.

THE TEETH.—Around one of the doors of the cupola is a most remarkable arrangement, which deserves a particular description. There is a slight resemblance, here, to one kind of wheels, with their component parts, or cogs.

There are, however, no wheels here. There is indeed something like a mill, and it performs some grinding; but the motion by which this grinding is performed is much like that of a pestle in a mortar. One of the segments of a wheel, with its cogs, stands still during the operation, while the other moves up and down upon it, and breaks in pieces the substances which come between. It also slides a little to the right and left, on the other, and thus performs its grinding process.

Look now at the engraving. This represents the left side of the bones of the human face, as it would appear if the outside of both the upper and lower jaw were split off.

When the number of teeth is complete, in an adult, and none have been lost, or drawn out, each jaw contains sixteen; and both, of course, thirty-two. In the engraving, you see there are eight teeth above and eight below; that is, just half of the whole. Children have but twenty at first, or ten in each jaw. These twenty are sometimes called the milk teeth, because they appear while the child's principal food is milk. These they shed, between the ages of seven and fourteen years; and thirty-two new ones grow in their place.

There is a period in every child's life—say at about the age of six years—when, if it have not yet begun to shed its first set of teeth, there are *forty-eight* in both jaws; twenty in sight, and twenty-eight beneath them, lying deep in the jaws, at their roots.

When you look at the jaw-bone of man, or any other animal, however, you do not see the roots or fangs of the teeth. They are encased or buried deep in the jaw. Those in front have only one root each; the grinders, or double teeth, have two, and sometimes more.

There are four kinds of teeth in each jaw, viz., four front teeth, two canine teeth, called also eye teeth, four small grinders, and six large grinders. Of these, half are of course on each side.

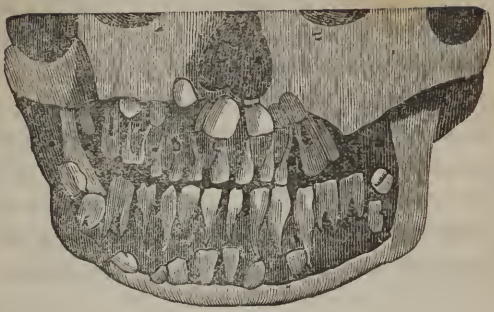
The fore teeth and eye teeth have but one root each. The small grinders do not often have more than one, but they are usually indented lengthwise, so as to give the appearance of two. The large grinders of the lower jaw have two roots, and those of the upper have three—two before, and one behind, or on the inside.

Who does not admire a good set of teeth? With some people, they are one of the principal marks of beauty. But they are *useful*, as well as handsome, as long as they remain sound. The teeth of some persons remain sound and beautiful all their days. Would you like to have yours do so? Let us then attend to the following particular account of them; and perhaps when we know their nature and structure better, we may better know how to take care of them.

Like the rest of the bones, the teeth consist principally of earthy substance—I mean lime. But at first, we can hardly be said to have bones in us of any kind. Some have begun to be a little solid, others have not. Where the bones afterwards are, we find a piece or lump of something which is nearly transparent, and more like jelly than bone. This in time ossifies, that is, becomes solid ; and forms bone.

Growth of the Teeth.—The teeth, as well as the other bones, are at first pieces of jelly. They do not appear at birth, for they are in the jaw-bone. And what may seem strange to you, the lumps of jelly-like substance which make *both* sets of teeth, (those which are shed early and also those which come afterwards in their place,) are there ; one near the edge of the jaw-bone, and the other a little deeper within it.

It will greatly help you in understanding me, if you will examine the following engraving. It shows the teeth as they appear in a child, before he has shed many of the first set.



When the soft pieces of jelly which form the teeth become *bone*, the process is as follows:—First, a hard speck commences in the centre of a tooth, and this gradually grows larger till all the jelly is gone, and ts place is taken up by bone.

The teeth, however, consist of something else besides solid bone. If they did not, they would very soon wear out. Do you think a piece of common bone, put in place of a tooth, would last us to chew with half a century or more? By no means. "But what then?" you will say. I will tell you.

STRUCTURE OF THE TEETH.—Each tooth consists of three parts—the *crown*, the *neck*, and the *fang*. The fang or root is the part which is set firmly in the jaw-bone, as if it were driven in like a nail. The neck is close to the edge of the jaw, where the thin skin or membrane which covers the jaw-bone joins to the tooth and adheres to it. (It is this membrane which the dentist separates from the tooth with his lancet, when he is going to extract it.) The tooth is a little smaller here, like a neck, or as if a cord had been tied tightly around, and indented it. The crown or body of the tooth is that part which we see above the gum. Every tooth has blood, and feeling in it; but of this I cannot tell you the particulars now. You will find more about it in another chapter.

Now to prevent the teeth from wearing out, as a piece of common bone would, this crown is coated all over with something much harder than any bone in the human body. It is called *enamel*.

USES OF THE TEETH.—Hard as it is, however, enamel will wear out in time. It will

wear out much sooner for picking the teeth, as many do, with pins and needles. These things are too hard, even for the hard enamel, and are apt to crumble it off. So is the wretched practice of cracking nuts with the teeth, or indeed the biting of any substance harder than the crust of good dry bread. If used to bite nothing harder than that, and if not injured in any other way—for there are a thousand ways of injuring the teeth—they may perhaps last all our lives. But if the enamel once gets broken away, so that the air and other substances come to the softer bone under it, the tooth soon becomes hollow, or decays. Like any other part of this wonderful frame which God has given us, the teeth will, however, last the longer for being *moderately* used.

Those kinds of food and drink which injure the stomach, injure also the teeth, and cause the enamel to become soft and break away. *Why* this is so, is a question which it would take too long to answer here; but you may believe the fact. In another place, I shall probably say more on this subject.

One thing, however, now. You should keep your teeth clean. After eating anything,

always rinse them well. And if you rub them with a soft brush several times a day, it may do some good in the way of preserving them.

Bones of the Ear.—About three quarters of an inch within each of the two side doors of the cupola—the ears—is a film or membrane drawn tightly across the passage, like a drum head. This is called the membrane of the *tympanum*—tympanum being the Latin word for drum; and a cavity behind the membrane is, of itself, called the tympanum.

In this latter cavity are four small bones. For what purpose they were intended by the great Creator, we do not know; but they are undoubtedly somehow concerned with the sense of hearing. Sounds reach the brain through the passage of the ear; and if there

were no ear, we should hear no sound. He who made the ear for sound, doubtless made all parts of it. And there is good reason to believe that every part of it is useful.

The bone at *a* is called the *malleus*, because it has been supposed to resemble a mallet or hammer; but it looks as much like a crooked club, with a branch sticking out from it, as like either. It is close to the tympanum, and touches it.

The *incus*, or anvil (*b*,) is the next. I think it looks as much like one of the smaller double teeth as like an anvil.

A little farther on is the little ring, (*c*.) It is very small, and seems to connect the incus to the stirrup. Anatomists, however, do not call it a ring. They call it by the hard name of *os orbiculare*. *Os* means bone, and *orbiculare* means ring-shaped.

The *stapes*, or stirrup, (*d*,) you cannot help knowing by its shape. It is the farthest within the head.

This little chain of bones is stretched along in the passage from the outside towards the inside of the head, beginning at the tympanum,

and ending at a small opening at a considerable distance within the head. They stand in the engraving nearly as they do in the right ear of a person, with the malleus outward, and the stapes inward towards the brain.

Bone of the Throat.—It is proper to mention, in this connection, that there is a curious little bone inside of the neck, near the root of the tongue, called the *hyoides*, or *os hyoides*. This little member has been supposed to resemble the Greek letter *v*, but it appears to resemble our own letter U nearly as much. You will examine it for yourselves.

This bone has something to do with keeping in their proper places the parts of the body which are concerned in speaking, chewing, swallowing, &c.

CHAPTER VIII.

THE HINGES.

The Hip Joint. Shoulder Joint. Elbow Joint. Ligaments. Capsules. Wear of the Joints. Synovia. Abuses of the Joints.

The house I live in differs in some respects, as you have already seen, from many other buildings. I will mention one important point more, in which there is a striking difference.

An ordinary building of wood, brick, or stone, is intended to stand firmly. No part, except perhaps a few doors, is made for motion. The ends of the parts are usually fitted together by square edged joints, with the greatest exactness. Then to complete the whole, and make the frame as firm as possible, girts, studs, braces, &c. are added.

There are indeed a few parts of the house I occupy, which are not intended to move much; but in general it is not so. Even the girts, braces and studs, are designed to regulate and direct motion, but not to prevent it wholly. And the joints, instead of being framed together by means of square tenons and deep mortices, and kept as dry as possible, are rounded and made smooth, and moistened by a sort of oil, to fit them for motion, rather than to hinder it.

There are indeed a few joints—if joints they ought to be called—which are firm and unyielding. I refer to the teeth. These, as we have seen, are set into the jaw bones, as firmly as tenons are into mortices, and more so. They seem to stand more like nails or spikes, when they are driven into planks or timbers. The bones of the head, too, are joined firmly together in adults, as you have already been told.

Some of the joints of the human frame are real hinges. To this class belong the knee joints, the joints of the toes and fingers, and those of the elbow. The lower jaw may also be called a hinge joint. The ankle joints, the

joints of the wrists, and indeed many others, sometimes move like hinges, but they perform other and very different motions besides.

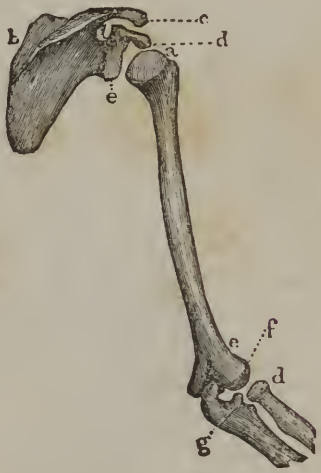
Hip Joint.—But the most curious joints in the human frame are what are called the ball and socket joints. The more important of these are at the shoulder and the hip. I will show you a cut of that at the hip.

At *a* you see the deep hollow or socket in the bone, where the round head of the femur

or thigh bone moves. This round head is drawn back from the bottom of the socket a little way, in order to show the round ligament near *a*. The latter is a very tough, strong cord, fixed by one end at the bottom of the socket, very firmly, and by the other, fastened to the round head of the femur. If it were not for this ligament, this joint would be dislocated, or slipped out of its place, a thousand times as often as it now is. At present, this very seldom happens. I ought also to say that there is a tough, gristly rim around the socket at the hip, which greatly increases its depth. This socket is called the *acetabulum;* meaning vinegar cup. It was supposed to resemble one kind of ancient vinegar cup, in use, I think, among the Romans.

I am now going to show you a picture both of a ball and socket joint and a hinge joint —the shoulder and the elbow. It must be confessed, however, that the hinge joint at the elbow is not quite so plainly seen as I could wish. But you have all seen door hinges no doubt, and the principle is the same. I know not but the first mechanic that ever

formed a door hinge took the idea of it from the hinge joint of some dead animal. But now for the engraving.



I will first describe the joint of the elbow. The lower portion of the arm is made up of two bones; one larger, called the *ulna*, and another smaller, called the *radius*. The upper end of the smaller bone, *d*, is a little rounded, and lies against a smaller hollow in the other

at *g*, to which it is tied by cords, called ligaments, particularly by one which goes round it like a band. The ends of these two bones, thus united, turn on the end of the upper one, which is rounded and fitted for the purpose, as you may see at *f*. They are kept together in a living person, (as indeed all bones are,) by broad and short straps or cords, called ligaments, which grow to each end of the bone a little way from the joint, and are very tight and strong, and yet not so tight as to hinder a proper motion.

But a ball and socket joint is rather the most curious. The bone which is represented at *b*, is the *scapula*, or shoulder-blade. The hollow place at *e*, is the socket in which the round end or ball *a*, of the upper bone of the arm, (the humerus,) plays freely, when we move the arm. The socket is so shallow, and the ligaments so long, in order to enable us to make almost every kind of motion with our arms, that it is much more easily slipped out of joint, or dislocated, than the hinge joints are. Even the hip joint, which is also a ball and socket joint, has a much deeper socket; and it

is on this account, that we cannot swing our legs round with quite as much freedom as we can our arms.

But though the shoulder joint is pretty easily dislocated, it is not so easy to put it in its place again, when it once gets out, as you may imagine. It sometimes requires all the skill of a wise surgeon, and all the strength of one or two strong men.

The number of hinge joints and other joints in the frame of the house I live in is very great. It must be nearly if not quite 150. I do not think there are many frames that have more hinges in them than the human. Some there are, no doubt, such as those large public houses, boarding houses, &c. But I was thinking only of those of ordinary dwellings.

You see the wisdom of the great Creator fully displayed in this structure and connection of the bones. What if the joint of the knee would move in every direction, like that of the shoulder? Do you not see that when we walked, the legs would have dangled about strangely, instead of moving backwards and forwards in one direction only? And is it not

plain that we could never have stood firmly? In like manner, how very inconvenient it would be, to have our finger joints move one way as well as another? On the contrary, how confined and cramped would have been the motions of the arm, if the shoulder had been like the knee, and had only permitted the arm to swing backwards and forwards, without our being able to carry it outward from the body?

The builders of machines have sometimes made joints in their machinery very much like the shoulder joint; but it is doubtful whether they could ever have contrived them, if they had not first looked at the bones of man, or some other animal; for other animals have these various sorts of joints, as well as man.

Ligaments.—But how are the joints held in their place? For when we take up a bone which has lain, perhaps for years, bleaching in the sun and rain, we only see the ends smooth, and some of them hinge-like; and if we take up two such bones, and put them together, they will not stay in that condition a moment, unless they are fastened by strings or wires, or

something of the kind. How, then, are they kept together in the living person? This is what I am about to tell you.

They are held together by short and strong straps, called ligaments. Some of them, however, are quite long, and begin at a considerable distance, say an inch or two, from the very end of one bone, and then, after passing over the joint, are fastened into the next. The strap or ligament does not adhere or stick to the joint, as it passes loosely over it, but is only fastened strongly, where it rises, and where it is inserted, as if it were nailed to the bone. The inside, where, in crossing, it lies against or rests gently on the joint, is very smooth; and is kept moist as well as smooth; so that the joint, in moving, may not grate or wear out.

These ligaments are white and shining, but not always very thick. They are very strong. Some of them are as narrow as a piece of tape. Others, as at the sides of the knee, or the shoulder, are very wide. Some cross each other, as at the knee. The latter are shown in the engraving. There are others still, that go all round the joint, and completely shut it

up. It is as if the ends of the two joints were put into the two open ends of a short cylinder, or rather of a short bag or purse, and the open ends were then gathered round, and fastened tightly to the two bones. Do you not see that, in this way, the joint would be completely shut up, as in a sack?

Capsules.—These bags or sacks are called capsules. Their use is to keep the joint from

being easily slipped out or dislocated. They are also intended for another purpose, scarcely less important—a purpose which shows the wisdom of the great Creator in contriving the human frame, more than almost anything I know.

The wagoner or stage driver has a mixture of tar, or perhaps tar and oil, some of which he often puts upon the axle of his carriage, where the wheel turns upon it. If this were not done, the axletree would soon become very dry, and the wheel would wear it. If the carriage were driven very fast, it might happen that it would take fire; for rubbing dry wood together, as you know, will produce fire. More than one stage coach has been set on fire, in this way, within a few years.

Wear of the Joints.—Now what prevents the joints of the human body from wearing out rapidly, in the same manner, when we walk much, or run swiftly?

The Father of the universe is the preserver as well as the creator of this "wondrous

frame." Were there not something done to keep these joints oiled, if I may so call it, they would not last long. Take the knee, for example; and think what a vast deal of friction or rubbing together of the end of the thigh-bone and of the two leg bones, there must be.

Why, a traveller probably swings each leg, in walking, about 1200 times in a mile. If he should travel 40 miles a day—and many travel more than this—it would be 48,000 times a day. If he should continue to walk only 30 miles a day all the year except Sundays, he would, at the same rate, swing each knee 15,024,000 times.

If he should do this every year, from the time he was 20 years old till he was 70, or for a period of half a century, the number of movements would be 751,200,000!

"A continual dropping," it is said, and it means dropping of water, "will wear away a rock." And the saying, though old, is true. Why, this continued rubbing of the bones of the knee together, if they were allowed to get dry, would wear them so much in a single day, that we should hear a grating noise at every

step, long before night. And, in a very few days, the bones would be completely worn out and unfit for use. I question if they would last even a whole day. Iron or steel, or even the hardest thing you can think of in the world, would wear out in a very short time. What, then, can be the reason why the knees and all the other joints do not wear out? There is no place to put in tar or oil, to prevent it.

Synovia.—I have said that many of the joints are completely shut up, as if by a sack. Now the Author of the frame has so contrived it, that a substance, called *synovia*, which answers all the purpose of oil or tar, continually oozes out on the inside of the ligaments at the joints, and keeps the ligaments themselves, and the joints, soft and moist. Can anything be more curious? Can anything prove, more clearly, a great Designer, or, as I might say, a great Master Builder?

One thing to be remembered is this:—The synovia or liquor which thus oozes out to lubricate the joints, will be of just the right quality and quantity when we are in the most

perfect health. If we are unwell, there may be too little or too much, or it may be too thick or too thin. When we use food or drink that is too heating or irritating, it seems to dry the blood, and after a while, the synovia will become less in quantity or of poorer quality. Persons who use much spirits or opium, or eat improper or heating food, are very apt, in the end, to have a grating in their knees when they stoop.

Such persons often run to the "doctor" to inquire what the matter is; but they might as well take care of themselves. Prevention—where we can prevent anything—is better than cure. Those who live on a small quantity of plain food, and drink nothing but water, and work at something steadily, but moderately, rarely have any trouble of this sort.

It has been said, that the ligaments hold the joints together. They do; but the tendons or straps, which go off from the ends of the muscles, and are fastened into the bone, beyond the joint, help greatly to hold it together. There are some very ingenious contrivances to keep the joints firm and yet movable, which I have not room to describe.

Abuses of the Joints.—This is the best place in the book for speaking of certain abuses of the joints. Now that the great Creator made the joints to be used, is proved from their curious structure, and from the substance prepared to moisten them; but that they were not made to be used too violently is also proved by the fact that if thus used, they become diseased. Sometimes the liquor called synovia dries away; in these cases, we hear the grating sound already mentioned; at others, the joints become painful or perhaps swell. It is rather seldom, however, that they swell from mere walking, if we walk ever so much; but they very often become stiff and clumsy.

One of the worst abuses of the joints is by wrestling. I have seen a great many famous wrestlers, who, when they became old, had stiff, or lame, or swelled knees or hips. They are tortured almost to death with these complaints. Sometimes the physician calls the complaint gout, sometimes rheumatism.

No doubt people have both the gout and the rheumatism from other causes besides wrestling, such as catching cold, excess in eating and

drinking, the use of spirits, tobacco, &c. &c. But it often happens that wrestling, when it does not produce all the mischief, unites with other causes to produce it; but sometimes it does the whole. In fact no person can use his joints with great violence, either in wrestling or in hard labor, without suffering from it, especially when he becomes old, if he lives to see old age; which, by the way, is not very common.

CHAPTER IX.

REVIEW.

Number of Bones. Skeletons. Anatomy. Physiology. Uses of Bones.

Number of Bones.—Let us now sum up or review what we have learned. This is always important in the pursuit of any study. Some teachers review every week, and some oftener still. Your parents or teachers, while you are studying this work, will, I hope, require you to review, at the end of every chapter.

The *cranium*, or part of the head which holds the brain, consists of eight different bones. There are fourteen bones of the face, besides thirty-two teeth. Then there are four very small bones in each ear, and one at the root of the tongue. Thus the whole head, above the neck, contains sixty-three. The

neck has seven; but as these form the upper part of the spine, they are usually reckoned with those of the body.

The spine, or back bone, contains twenty-four pieces, called vertebræ; and between these and the lower extremities are four bones more. There are twenty-four ribs, that is, twelve on each side, and a breast bone, or sternum. Thus the whole of what we properly call the body, has fifty-three bones.

The whole upper extremity, including the hand, arm, *clavicle* or collar bone, and *scapula* or shoulder blade, consists of thirty-two pieces; or sixty-four on both sides.

Each lower extremity includes thirty bones; or both of them sixty; besides the small sesamoid bones.

Now if we add up these several sums, we shall find the amount two hundred and forty. A complete human skeleton, then, would contain no less than two hundred and forty bones! Who would suppose so, from a mere view of an individual, while in the act of standing? But when we come to see him walking or in motion otherwise, we begin to find he has a

great many joints in him, and of course a great many bones. There is more or less of motion, where nearly all the bones of the frame meet, if we except those of the cranium, face, teeth and pelvis; and these may all be moved in nearly the same instant. Thus there are, in the human frame, about one hundred and eighty joints!

We ought also to add to this number the small sesamoid bones, found in the thumbs and great toes of older persons, and somewhat resembling the knee pan in shape. Of these there are often two in each large joint of the great toe, and as many in the large joint of each thumb. Adding these, then, to the two hundred and forty, we should have for the whole number of bones in the human frame, two hundred forty-eight.

Some make the number about two hundred and sixty; but they reckon fourteen sesamoid bones. It should be remembered that the number of the sesamoid bones varies greatly in different persons, though nearly all adults have some of them. They are hardly ever larger than half a pea. Some individuals have them

in other parts of the body, besides those already mentioned.

It should also be observed, that there is a small fragment of something which is bony in its appearance, usually found in the very middle of the soft part of the brain. What the use of it is, nobody knows, except the Creator.

Besides all this, the breast bone, the ossa innominata, and many other bones of the body, are in several pieces, while we are young; and some of them are not very strongly united, even when we are old.

Nor is this quite all. A few persons may be found, who have a still greater number of bones; but these are properly diseased persons. A bony or chalky substance is often found in the flesh of those who have the gout. Some of the gristly parts of the body—I mean the cartilages and ligaments—occasionally change into bone; and so do small portions of the great arteries or tubes which carry the blood. In some diseases, too, the bones separate into several pieces. Here and there we find a person with six fingers on each hand, or six

toes on each foot, and sometimes with both; but these supernumerary fingers and toes do not always have bones in them.

Skeletons.—When the bones of an animal are put together, and fastened to each other by pieces of wire, the whole is called a *skeleton*.

There is another kind of skeleton, but it is not so common. It is made by stripping off all the soft parts of the body, except the ligaments; these are suffered to remain. The whole is then very thoroughly dried. This saves the trouble of having wires.

The engraving represents the human skeleton fastened together by wires, in the usual manner. It is represented in this posture in order to give you a different view from that opposite the title-page.

Anatomy.—The study of the nature and structure of the bones, and nothing but the bones, is called *osteology;* that of the muscles,

and nothing else, *myology*, &c. But as most people who study these, go farther, and learn also the shape and structure of the heart, the lungs, the brain, the blood-vessels, and, in fact, all parts of the body, some more general name would seem necessary for what they do. So we say of those who study all parts of the human body just as it appears the moment the soul leaves it—bones, muscles, tendons, brain, nerves, heart, blood-vessels, lungs, skin, &c., that they are studying Anatomy.

Physiology.—Physiology is something more than all this. It is the study of the living animal;—how the heart, the brain, the eye, the ear, the muscles, the bones, and every other part, act—and their uses; and an interesting study it is, too. David, the king, probably believed so, when, after thinking about the curious structure of his own body, he exclaimed, "I am fearfully and wonderfully made."

King David, however, had probably never seen a complete human skeleton; for in those days, it was generally thought very wrong to use the dead body of a human being for any such purpose. But of late years many people

think it quite right to dissect (separate) dead human bodies, if by so doing they can learn how to cure or prevent diseases of the living. Not very often to be sure; and only the bodies of criminals, such as have no friends, relatives, &c.

In making this little book, it is my object to teach you something of both Anatomy and Physiology. I have yet done but very little, and what I have done, has been chiefly in Anatomy.

The remaining chapters of this book will embrace much more of Physiology. It will consequently be a little more difficult to understand it; but it will also be much more pleasant, when once understood. There are yet many wonderful things to be known about your bodies.

USES OF BONES.—Before I close this chapter, you must allow me just to say that bones are often used in the arts. Ivory is nothing but bone—the teeth of the elephant. The bones of man, so far as I know, have not been used in any of the arts.

The shells of many of the *testaceous* and *crustaceous* animals, are of very great value. Such are the tortoise shell, the pearl, &c.

The shell of the tortoise, in particular, is exceedingly valuable in the arts. You will observe that these shells to animals, not only serve as a support to their softer parts, but also as a defence. What would become of the tender frame of the poor tortoise, lobster, crab, and oyster, if they were not covered over, as with a shield, by a hard buckler of shell? The soft parts of the human body are, in many instances, well defended by the solid frame on the outside of them, in the same manner. Such are the brain, the spinal marrow, the lungs, the heart, and the liver.

Now one principal part of all the shells of animals is lime. So that there is not so much difference between the bones of man and the shell of the tortoise or the lobster, as you may have supposed, though the color is somewhat different. A very large proportion of the lobster shell is lime; in the tortoise shell the proportion is small. Horn has but a very little lime in it.

There is one use made of the bones of the human frame which it is rather shocking to think of. It is well known that the bones of other animals make a very excellent manure for enriching the soil; but it is not so often understood that the bones of men are used for this purpose; and some of you, it may be, never heard of the fact.

You have read, I presume, about the great battles which were fought in Germany and France many years ago, in the time of Napoleon Bonaparte; when thousands of men were often left dead on the field, and their bones sometime afterward almost covered the ground. The Germans have long used bones as a manure, in their hot houses.

Within a few years, these human bones, it is stated, have been brought to England, and ground by means of steam-engines and other powerful machinery, and used as manure. It is computed that in 1832, a million of bushels of bones of men and horses, were brought from the continent over to England, and used by the farmers of Yorkshire, Nottinghamshire, and the neighboring counties.

In our own country, the horrors of war have not usually been dreadful enough to render bones so abundant and cheap that we can use them in this way. The bodies of men slain in war, as well as those who have died in peace, have, in general, been decently buried. May we not hope that our country will never be deluged with blood and covered with bones, as some of the countries of Europe and Asia have been? May we not hope that at our death, our bodies will be buried quietly in the usual manner—"ashes" returning "to ashes," —"dust to dust,"—and the soul to the "God who gave it?"

CHAPTER X.

COVERING OF THE HOUSE.

The Periosteum. The Muscles. The Tendons. Structure of the Muscles. Action of Muscles. Illustrations. About Fat. Reflections.

The covering of the house I live in differs more from other buildings—that is, possesses more peculiarities—than almost any other part of it. In covering an ordinary wooden building, it is usual, in the first place, to line the frame. This lining is often but not always very thin. Next to the lining comes a covering perhaps of thicker boards; and lastly, a layer of shingles or clapboards. Between the latter and the boards under them, however, upon the crevices or cracks of the boards, they often put birch bark, or tarred cloth, or paper, to keep the snow and rain from penetrating.

But in covering the house I live in, there is a long process to go through with, before we come to anything like this. I will attempt to describe it.

The habitation of the soul contains no sharp corners or square edges. Everything, even the smallest part, is more or less rounded. It seems as if the great Architect regarded roundness as a beauty, and squareness as a deformity. But in a wooden building, and indeed in those of brick and stone, square sides, square edges, &c., appear to be regarded by the architect as points of beauty. The sides of timbers, especially, are left square. Strip off the covering from the outside, or the plastering from the inside, and you expose to view, at once, these square sides and edges.

THE PERIOSTEUM.—How different the structure of the house I live in! Every bone in the frame, as if to prevent the possibility of having any rough sides or corners, is neatly covered with a very thin gristly substance, which is called the *periosteum*. *Peri* means around, and *osteum* means the bone or bones.

It is, in fact, a thin but tough cartilage. There is a plain reason for this periosteum being used. The frames of houses, &c., are made to stand firmly; they are not intended for motion; but the frame, and almost every part of the human body, is made to move. But where there is motion, it is desirable that the parts should be rounded as much as possible, and every possible pains taken to prevent friction or wearing.

After every bone* is covered over with this thin substance, we have next the muscles and tendons. It is the muscles generally, which give soundness and beauty to the human body and limbs. A large number of them are situated on the bones, especially the long bones, but some are extended between them. The bones are generally smallest in the middle,

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* Or rather every bone except the teeth. The teeth, where they stand out of the gums, are covered with enamel. A thin membrane like the periosteum, would do no good, as it would soon wear out in eating. The ends of the bones also, where they rub against each other—I mean at the joints—are covered with a white elastic substance, which is not exactly like the periosteum.

and increase in size towards the extremities, at the joints; but the muscles are usually the reverse of this. They are largest towards the middle of the bones, and grow smaller towards their extremities.

We have a striking example of what I have just stated in the case of the arms. The bones of the arm, as seen in the skeleton, are so large at the joints and so small in the middle, as to make the limb appear almost frightful. But when we come to see it dressed up with muscles and covered with the skin, it is very well proportioned. The elbow in most persons is scarcely larger than the arm is, both above and below it. Now this is done by means, as I have said before, of the muscles. They are larger where the bones are smaller, and grow smaller till they come near the joints, where they run into tendons.

But before I go farther, I must tell you what muscles and tendons are.

THE MUSCLES.—The muscles are the flesh, —I mean the lean part of it. They are of a reddish color, as you have probably observed.

The red color is caused by the blood in them; for it is not only true that blood, in small veins and arteries, runs through them in every direction, but it also tinges their whole substance. We know this is so, because when the muscles have been soaked and boiled long enough, their redness disappears. Even when boiled for the table, the muscular parts of animals are of a paler red than they were when they were first separated from the mass of flesh to which they belonged.

THE TENDONS.—Some of the muscles are fastened at once to the bones, and grow into them. In this case the covering of the bones, or periosteum, seems like a sort of glue, intended to cement the muscle and bone together. But in general, the muscles are not themselves fastened to the bone. They terminate towards each end, by one or more tendons. These tendons are white, flattened substances, like belts or straps, and are very tough and unyielding. When boiled with the muscle to which they are attached, they are sometimes called whit-leather; and it is almost as difficult

to break them to pieces with our teeth as if they were of real leather. The muscles, then, usually terminate in tendons, and it is the latter which grow to the bone; though the muscles sometimes grow to the bone directly at one of their ends, without the help of tendons.

Structure of Muscles.—The substance of the muscle is thready or fibrous. You have probably observed that a piece of lean meat, when boiled, has this thready, fibrous appearance. There is one thing about muscles which does not so readily appear after boiling as it does before. A piece of meat to be boiled, is cut off in such a manner that it usually takes parts of several different muscles; and the whole, in this way, seems like a solid or nearly solid mass; whereas it could be parted out, with a very little care, each muscle by itself. Such is the case with a piece of flesh taken from the leg of the ox; and such would be the case with a piece taken from the human leg or arm. These separate muscles are connected to each other by means of what is called cellular substance,—a fine woolly sort of membrane

which I shall have occasion to describe hereafter. Each thread or fibre of each muscle is also connected to each other fibre which lies next to it, by the same sort of cellular or woolly membrane.

Thus, as you see, a mass of lean flesh, such as we boil, and such as we see on cutting into the limbs or other parts of an animal, consists of smaller bundles of flesh, connected together by the cellular membrane, but not so tightly as to hinder each bundle or muscle from moving or sliding about a little among the rest. Now each muscle, in like manner, consists of a great multitude of fibres, also connected together by cellular membrane. It is also thought by many anatomists, that each fibre is made up of a great many smaller fibres, so small as not to be seen by the naked eye.

The number of muscles in the human body is very great. Anatomists do not agree about the number, because there are many which some reckon as only one muscle, while others call them two, (for they have really a double appearance;) and because a few are so small that some do not count them. They are

usually, though not always, arranged in pairs; that is, there is one on the right side of the body exactly like one on the left side opposite to it; and so on. We cannot reckon the whole number at less than four hundred and fifty, and some make it above five hundred and twenty.

I have said that these muscles—many of them—end in tendons, or thin whitish straps. Sometimes they end in two tendons. The *biceps*, as it is called in books, a muscle that lies on the arm, and has one end fastened at the shoulder and the other at the elbow, has two tendons at the upper part.

I will show you an engraving which will give you a pretty correct idea of the shape of the muscle I have just been speaking of, as well as of muscles and tendons in general. You must remember, however, that only a few muscles have double tendons, as this has; and that they are far from being all of them as perfect and beautiful as this. Some are quite ill shaped, and irregular in their appearance.

Action of Muscles.—In front of St. Peter's church at Rome, stands an obelisk of red Egyptian granite, 124 feet high. It was brought from Egypt to Rome, by order of the Roman Emperor Caligula. However, it lay

partly buried in the earth where it was laid down, till about 250 years ago, when Pope Sixtus V, by the help of forty-one strong machines, eight hundred men, and one hundred and sixty horses, succeeded in eight days, in getting it out of the ground; but it took four months more to remove it fifty or sixty rods farther, to its present situation.

When they had reached the spot, the grand point was to raise it. They erected a pedestal or foot piece, shaped like four lions, for it to stand on; and by means of powerful machines and many strong ropes and tackles, they placed the bottom of it on the pedestal. Then they began, with their machinery, to raise it. But when it was nearly up, so that it would almost stand, the ropes, it is said, had stretched so much more than the master workman expected, that it would go no farther.

What was to be done? Fontana, the master workman, had forbid all talking; and they now stood holding upon the tackles so silently that you might have heard a whisper. Suddenly an English sailor cried out—"Wet the ropes." This was no sooner said than done; when, to the

joy and surprise of everybody, the ropes shrunk just enough to raise the obelisk to its place, where it has now stood nearly 250 years—and where it may perhaps continue to stand many thousand years, unless an earthquake should shake it down.

You will probably begin to wonder what this story has to do with anatomy and physiology. I will tell you. The muscles are the parts by means of which we move our heads, our arms, our legs, &c. In fact, we could not so much as move a finger, or any part of our bodies, without them.

But they move these parts by contracting or shrinking. Being fastened to the bones at each end, they must, you know, if they shrink, draw one of the bones to which they are strongly fastened towards the other. If the muscles between the shoulder and elbow shrink, they must either draw the shoulder towards the elbow, or the arm below the elbow towards the shoulder. You can judge for yourselves which would be most likely to happen.

The muscles will not contract or shrink a great deal, it is true; but they will do so much

more, in proportion to their length, than wet ropes will.

Illustrations.—I must explain this matter by another engraving. Here is a picture of the right arm. It is represented as if everything was cut away from the bone, except the single muscle of which I was just now speaking, (the biceps,) and the skin. It is represented, too, as already shrunk, and the arm drawn up as far as possible towards the shoulder. You see how large this muscle is in the middle, when thus contracted, and also the point at which it is inserted below the elbow.

In one respect, a muscle does not shrink *like* a rope; for the latter, when it shortens, or grows larger, swells all the way alike; but when a muscle contracts to draw up a limb, it swells chiefly in the middle. Some muscles do not swell so much as this, when they shorten, but they are all enlarged more or less, when they move any part of our body.

Perhaps you do not yet understand how a muscle, by contracting or shortening, pulls up the arm. I will endeavor to make it more plain.

I now sit at my table—my right arm lying on it. For the sake of explanation, I will consider it as helpless as a stick of wood. Now if I wish to get my hand to my head, how is it to be done? If a piece of dry rope, fastened by one end at the shoulder, and by the other to my hand, were moistened, it would shrink a little, and raise my hand a little way from the table, but not very far.

But suppose the lower end of the rope were fastened round the middle of my arm, and then made to shrink; would it not raise the hand higher than before—I mean, if the

elbow remained where it was? It certainly would. Still it would not bring the hand up to the head, nor half way to it. But suppose once more, that the lower end of the rope were fastened still nearer the elbow. The nearer it is, the farther it draws up the hand, when it shrinks.

Now the end, or *tendon* of the muscles, which shrink to draw the hand up towards the head, is fastened to the arm below the elbow; but is close to it, so that, in shrinking only an inch or so, it draws the hand up to the head. If you lay the other hand on your arm, between the shoulder and the elbow, you can feel it contract, and at the same time see it swell out.

If the lower end of the tendon of this muscle were fastened lower down, that is, farther from the elbow, it would start out so far, when we raise our arm, as to make a very singular appearance, unless a band were put around it at the elbow, to keep it down, which would have been very inconvenient. As it now is, the tendon starts out a little way, as you may see by the engraving, and as you may know by

placing your hand on it, or under the knee, while you are bending a limb. But as the matter is contrived by the great Architect, it renders the arm very useful, gives it a good shape, and ought to raise our thoughts in gratitude to infinite Wisdom.

One illustration more. Suppose I am sitting at church, with my pew door open, and wish to close it without disturbing anybody. Shall I take hold of it near the hinge, so that a little moving of my hand and arm will answer the purpose, or shall I take hold farther off? Again, suppose a rope were to do the work—would not one which should be tied to the door close to the hinge, and then made to shrink, say an inch, draw it together much more than if it were tied at the distance of a foot from the hinge? It is true that, in shutting a door by taking hold close to the hinge, we must pull *harder* than if we did not; and so it is with muscles, like those which move the arm.

From the course of these remarks, I fear it will be thought that there is only one muscle concerned in bending the arm. The truth is, that in performing almost any motion of the

body, a great number of the muscles are employed. In moving the hand alone, we use nearly forty; and in using the whole arm, not much less, I presume, than one hundred.

If you look on a skeleton, (see page 107 and the frontispiece,) you see how the bones at the joints project, and also how ragged the spine and many of the flat bones appear. Now the several hundred muscles of our frame fill up all these spaces, cover the ragged bones, and produce that smooth sur ace which we see on a healthy human body.

The change which takes place is something like that which would happen, if we were to take some rather soft pliable substance, as hemp, and not only wind it about all the side-pieces of timber in a wooden house frame, but extend it across from timber to timber, until the whole were so filled up and rounded as to appear like an even and regular surface, instead of a broken range of pieces of timber, with large vacancies between them.

About Fat.—But I must not leave the impression that the muscles and tendons perform all the "filling up" of the human frame,

for it is not so. They are covered again by the skin, which is to be described in the next chapter. Nor is this quite all. There is in most persons a small quantity of fat, intermixed with the muscles; and in some persons a great deal of it. This fat is found in the soft, white, cellular substance which is placed everywhere between the muscles, and the little bundles of which they are made up. You will now be able to understand and remember the meaning of the word *cellular*, for it means made up of cells, something like honey-comb; and the fat is deposited in these cells. Only a small quantity of fat is necessary to health; and when it is found in unusually large quantities, in man or in other animals, it shows that they are diseased.

Reflections.—Thus we see that the great purposes which the muscles and tendons subserve are, the filling up and beautifying of the frame, and the motion of its parts and of the whole. We should be more helpless than the brutes are, if we had no muscles. Indeed, as we could not move a finger without them, we should be more miserable than any other animal; for all animals have muscles—even those

which, like some shell-fish, hardly know enough to change their place.

But with the hundreds of muscles which we now possess, how multiplied are our motions! For you must recollect that not only the movements of the head, arms, hands, fingers, back, legs, toes, &c. are performed by these means, but also the movements of the very chest itself in breathing, unless, as is the case with some unwise or ignorant mothers, we confine the latter by tight clothing. More than all this, the curious processes of chewing and swallowing our food, and of speaking, singing, crying and laughing, are chiefly done—not without the aid of the teeth, it is true—by means of the muscles.

The muscles have other uses still, besides those of beauty and motion; but the reader is not prepared to understand what they are, till he knows more about the blood and the circulation. In describing the circulation of the blood, I shall be likely to make the matter plainer, by far—and with fewer words than I could possibly do it in this chapter.

CHAPTER XI.

THE COVERING.—BOARDS AND SHINGLES.

The Skin. Coloring of the Skin. Change of Color. Oil Glands. Pores of the Skin. Cleanliness. Hair and Nails.

No part of the human structure is more favorable for carrying out the similitude of a house, than the skin. If we were to regard the body, to the extent I have now described it, as the mere frame of the building—though in reality the bones and ligaments alone constitute the frame work—the skin would compare almost exactly with the clapboards and shingles. For there is first a thin series of lining boards, then a layer of thicker boards, and then the shingles or clapboards.

A coat of paint is also applied in both cases; but the place of application is somewhat differ-

ent. In a common wooden building, the paint is applied to the outside; but in the house I occupy, it is put between the clapboards and the thick boards under them.—But to be a little more particular.

THE SKIN.—I have already told you what cellular membrane is. Now the first layer of the covering of the house I live in, consists of this membrane, in pretty large quantity, and as it were firmly pressed together. That it is the very same sort of membrane—full of little cells—is proved from the fact that if you insert a quill into a small hole through the middle layer of the skin, which I am about to describe, and blow with your mouth or a bellows, you can fill these cells, all over the body, with air; and a small animal, like a rabbit or a squirrel, will look almost as round as a foot-ball.

Next to this is the middle layer, or what answers to the stout, rough boards of a building, on which the clapboards are laid. This, and this alone, is the real skin, or that which, in the case of the ox, deer and other animals, makes the leather. In tanning, currying and

dressing skins, the cellular layer just now described, the layer which remains to be described, and the paint, are all scraped off, and nothing remains but the true or real skin—the layer now under consideration.

I do not mean to say here that leather consists of nothing but this skin, for I know that tannin, as the chemists call it, combines with the raw hide, to make most kinds of leather; but I mean that no animal substance goes to form the leather, except this single membrane.

This membrane, or real skin, is principally composed of an almost endless number of small blood vessels, running along and crossing each other in nearly every direction, together with nerves quite as numerous, intermingled with them. The nerves, however, seem to be enlarged on the surface of this membrane, and to form little rows of eminences or pimples. These are seen plainest on the tongue, and on the balls of the fingers; but exist, of a small size, all over us. You cannot prick the skin with the finest needle in the world, without hitting at least one nerve and one blood vessel. For there would be pain in doing so; and this

always shows that a nerve is wounded. A very little blood would also flow, which shows that you have hit a blood vessel.

Coloring of the Skin.—Now we are come to the place of the paint—the color of the human body. For so far as I have already described the skin, the color is exactly alike in all people, black, red or white. Here, spread over the true skin—the part which forms the leather—on a thin gauze-like membrane, and under the outside membrane not yet described, is a soft pulpy or jelly-like substance, containing the color. In the African, this pulpy substance is black; in the native American or Indian, it is red or copper color; in the Asiatic, it is yellow, and in the European, white. In mixed breeds, it is of course of the various colors which those mixtures exhibit.

I have sometimes been surprised to find how ignorant many people are on this subject of color. Some have never thought of it at all; others suppose that the whole mass of our bodies is darker or lighter, according to the indication of our faces; others suppose the color is in the blood; and others still that it is in the

true skin, or the part which forms the leather. But we see that none of these are right—that the skin itself, properly so called, is alike in the whole human race, that is, it would form leather of the same color in all; and that the color might be removed, though not without much pain, leaving one individual as white and as dark as another.

What good this color does is, I believe, unknown; or why all mankind could not just as well have been left wholly without it, and thus all have been really flesh-colored. In some parts of the skin, in the European race, there seems, in fact, to be but very little of it. It is only on the cheek, and perhaps the lips, that the color seems to differ much from that of the real skin itself.

I know that there have been a great many conjectures about the uses of this coloring matter; but there is very little true knowledge abroad concerning it. We know, indeed, that a dark skin, as it suffers the heat of the body to escape more rapidly than a light one, renders a person cooler in hot weather, in hot climates; but it would be difficult to believe that this is the principal reason for its existence,

Change of Color.—There is one curious fact which deserves to be mentioned in this place. It is that the coloring matter, in some persons, has been known to change. There have been several negroes, and I believe one or two Indians, in whom spots of a chalky white have appeared on their limbs, which enlarged and spread until the whole body became white. These facts, strange as they are, may be relied on.

It is not at all strange for other buildings to fade; but for the human habitation to lose its color, imbedded as the paint is under a hard, tough membrane, is rather unaccountable. But it is the result, no doubt, of disease.

The Cuticle.—But the mention of the membrane which covers this paint or pigment on the human skin, reminds me that it is time to describe it.

This membrane, which answers to the clapboards, shingles or tiles of a wooden building, is constructed almost exactly like the latter. Or perhaps it would be equally correct to say that it is formed like the scales of fishes. For anatomists who have viewed it with glasses

which magnify greatly, say that, thin as it appears to the naked eye, such is its real structure. It is called, in books, the cuticle, or scarf-skin, and sometimes the epidermis; in short, it has a great many names; but cuticle is the best.

The cuticle is the part which rises when the skin is blistered. If you examine it when it is thus raised, however, you will be a little disappointed in regard to its structure; for it is then so soaked with the water of the blister, and so much thickened, that it does not appear at all natural. In its healthy state, it is scarcely a fiftieth part as thick as the covering of a blister; besides which, it is transparent, or nearly so. If it were not, you could not see the coloring matter under it so plainly.

You will get the best idea of this cuticle which the naked eye can give you, by examining it when you have by accident grazed off small portions of it. I have often grazed it from my leg, when a boy; and sometimes I have grazed a little too deeply.

These grazed places soon heal, however, if we are temperate, and correct in all our habits,

though I have known an old man, who was intemperate, to have a sore and lame leg almost a year, in consequence of a slight wound that would have healed in a week, had he been temperate.

The most surprising fact in regard to the cuticle is, its power of being reproduced, or growing again. If grazed off, or if it peels off, after a blister or swelling, a new cuticle appears with so much rapidity that one would be tempted to think it was already formed under the old one, as the new teeth are under the old ones, which they push out. But it is not so. The new cuticle never grows till the old one is either separated or dead.

The coloring matter, if destroyed, grows again, or appears again, almost as soon as the cuticle does. But the real skin, which I described just now, if once destroyed, never grows again. This is the reason why scars are produced on us. The loss of the cuticle or the paint never causes scars; but that of the real skin always does. It is true the place is sometimes filled up with a substance which strongly resembles skin, and which answers the purpose,

but it is never real skin; and this is the reason why it remains a scar.

Oil Glands.—No process has ever been devised, so far as I know, by which the outside of a building can be oiled of itself, without manual labor. Nor is it common or necessary to apply oil to a building, except in the form of paint, which is partly oil.

But the animal frame seems to require frequent oiling; and, in some of the feathered tribes, it is done by the beak. They have a little gland, as it is called, which furnishes them with oil. This oil they press out with their bills, and then apply it to their feathers, which also overlap each other like shingles, that they may the better shed the rain.

But most other animals, instead of having the oil in a single bag or gland, have it in a thousand little glands, almost too small to be seen by the naked eye, and imbedded in the skin. They are very thick indeed in the skin of the sheep, and hence the wool of a healthy sheep is always quite oily. They are numerous, too, about the roots of the hair of most

animals; and hence it is that the hair—even the human hair—in a state of health, appears more or less oily.

This oil for the hair appears to be furnished by a multitude of little bags or glands lying near its roots, somewhat resembling a bottle in their shape, from the open neck of which oozes the oil.

In man, the hair of whose body is generally thin, this oil is in very small quantity, and is not very important to health. Those nations—and some such there have been and still are—who put on an additional quantity of oil, are far from being the most healthy. In fact, if the human skin is not often washed, to get rid even of its natural oil, it becomes a source of disease.

Pores of the Skin.—Besides the mouths of these little oil glands, many anatomists have considered the skin, and the cuticle among the rest, as pierced with little openings called pores, almost innumerable. Some have reckoned them at 1,000,000 to every square inch. Others, however, deny all this. But one thing

is very certain, which is, that what we call sweat, when it becomes abundant, is constantly escaping through the skin and its cuticle, in the form of a thick mist or fog, as we may see by holding a bright mirror close to it, which will immediately become tarnished. Or if we sit where the sun shines across us upon a wall, we can see the shadow of the mist which ascends from us, rising like a sheet of thin smoke upon the wall.

Cleanliness.—It is of less consequence to people to know how this moisture escapes, than to know the fact itself, and to know also that if this constant *perspiration*—for that is its name—is checked for any considerable time, mischief in the form of colds, fevers, rheumatisms and consumptions may ensue. Great mischief may also follow, if the perspiration is checked by neglect of cleanliness.

There are also other offices performed by the skin that are curious, but I will mention no more of them now. The more you understand the structure of this part of the frame, the more you will see how important it is that it

should be kept clean by washing, every day we live. And yet how many there are, who do not wash it at all, except perhaps their face and hands! Such persons are not fit to be entrusted with a habitation so fearfully and wonderfully wrought. In truth, they are not usually so long entrusted with it as others. The great Architect usually turns them out many years earlier than he would, if they took care of it; and in the case of cholera or malignant fever, sometimes thrusts them out with apparent though deserved violence.

The Hair and Nails.—This is the proper place for saying something about the hair and nails; for these, though not skin, are closely connected with it, and even fitted into it. The hair appears to be the proper covering for the head, but more pains are necessary to comb it and keep it clean than are commonly used; and for this and several other reasons, it is apt to become sickly and diseased, and to fall off.

In some parts of Europe, as among the peasants of Poland and Hungary, who greatly neglect cleanliness, and are addicted to other

filthy and bad habits, the hair becomes matted and worse than matted together, and a terrible disease ensues, called *plica polonica*. But in all countries, not only the hair, but the health in general, suffers more or less, if we long neglect cleanliness of any part of our bodies.

As to the nails, I can only say that they are intended to brace or support the balls of the fingers, so that we can use them the better in examining bodies by the sense of touch. Hence one reason why they should not be pared too closely; and hence, too, the reason why, when they are pared too closely, the ends of the fingers often become more or less crooked.

CHAPTER XII.

THE COVERING.—THE WINDOWS.

General Remarks. The Human Eye. Situation of the Eye. Coats of the Eye. Optic Nerve. The Tears. The Eyelids. The Eyebrows. Reflections.

General Remarks.—Before glass was invented, the windows of dwelling houses were small, and made in different ways. In summer, they often consisted of a mere hole in the side of the building. In the eastern houses there were no windows of any kind in *front*, or towards their neighbors; and in China, this is the custom to the present day.

In winter, these holes or windows were closed up with something which would partially exclude the cold, the rain and the snow. In some countries of Asia, and in ancient Britain, they used oiled paper for this purpose.

In France, besides oiled paper, they used talc or isinglass, white horn, and thinly shaved leather. In ancient Rome, the rich sometimes used very precious stones. Those in their bathing houses were often of agate or marble. The Chinese used a very fine cloth, covered with a shining varnish; and, afterwards, split oyster shells. They had also the art of working out the horns of animals into large and thin plates, which they used in the place of glass for their windows.

The first windows of common glass, that is, sand, potash, &c., melted together and formed into plates, were made in the time of Constantine the Great, in the fourth century after Christ. But it was not till the fifteenth or sixteenth century, that glass was brought into common and general use.

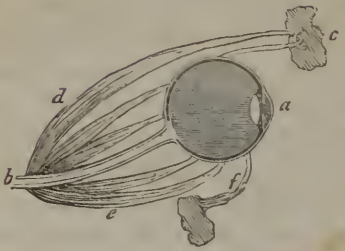
THE HUMAN EYE.—The windows of the human frame are made neither of paper, isinglass, agate, marble, horn, leather, cloth, oyster shells, or common glass. Nor are they confined to the back part of the house, like those of some eastern nations. Nor are they very

large or numerous. There are but two of them, and those not so large as a hen's egg. They are set in the front of the house, in the cupola.

Both of them open and shut—rise and fall, have the curtains drawn or removed, and the blinds opened or closed—at the same instant. Some windows are only made to be raised, that is, moved, in one direction; but these move every way, and with great ease and rapidity. It is done by means of pulleys, &c. The curtains may be drawn or removed almost with the swiftness of lightning, and hundreds of times in a minute.

Situation of the Eye.—The truth is that the human eye is almost as round as an apple, but not quite; for it projects out a little at the fore part. In an adult person, it is not more than an inch in diameter, and lies deep in a cavity in the skull. It is not *fixed*, like the eyes of some animals; but can be made to roll about, upward, downward and sideways. For this purpose, it does not adhere closely to the bone, but lies on a soft bed of fat substance, and has many muscles or cords fastened to the

sides and back part of it, as you see in the engraving.



If the eye of a dead person—say a criminal—was to be cut in two in the middle from top to bottom, with the handle of the knife held forward, and the point towards the back side of the head, a side view of one of these halves might be supposed to look like the engraving. A large whitish cord, which you see running from *b* to the back side of the eye, comes from the brain, and is called the optic nerve. The rest of the cords between *d* and *e* are muscles, or little bundles of flesh; and they become tendons, or white, hard cords, at the smaller part, where they are fastened to the eye. The upper one goes round a little piece of bone like a

hook, as you find at *c*. The lower one, *f*, is also fastened in a very ingenious manner.

The tendon that passes round a piece of the bone of the forehead, is fastened to the very top of the eye ball. Now it is easy to see that if the upper muscle at *d* should contract or shrink, it would operate just as if it were a rope, and somebody pulled it;—that is to say, it would pull the top of the eye ball forward, and make the fore part, at *a*, turn downward, so that a person would look towards his feet.

Coats of the Eye.—The eye is a large hollow sack, containing a clear but thick liquid, most of which is not unlike the white of an egg. The covering of the eye consists of several layers or coats.

The outside, or *sclerotic* coat, as it is called, can be seen in the engraving. It is very thin, and a small portion of it at the fore part is wanting. In this vacancy or opening is set the *cornea*, a piece of membrane which is transparent, that is, can be seen through like glass. This transparent part you will find near *a*. It is placed in the sclerotica, as a crystal is set in a watch; or, if we compare the eye to a win-

dow, just as a pane of glass is set in the frame; with this difference, however, that a pane of glass is seldom round, but the cornea is as round as a dollar. It also stands out from the eye, like the crystals of most watches. The rays of light enter the eye through this cornea, and pass to the back part of it. What we call the white of the eye is the sclerotica, or window frame, as far as we can see it, surrounding the cornea.

The *tunica sclerotica*, or sclerotic coat of the eye, is lined by another thin coat called the *choroides*. The internal surface of the choroides is covered all over, except at the back part, where the optic nerve enters, with a thin sooty kind of black paste, called by anatomists the *pigmentum nigrum*, which means black pigment. You see this represented very fairly in the engraving, and as this is spread over the choroides, and the choroides only lines the sclerotica, and does not extend to the cornea, you can easily see where the latter begins.

Where the sclerotica and cornea join, a kind of circular membrane or curtain runs inwards,

and is represented in the cut by two white lines approaching each other, but not quite coming together. When we look at the eye of a living person, this curtain is sometimes light blue; in other persons it is gray, hazel or black. When this curtain—called the *iris*—is blue, the person is said to have blue eyes; when black, he is said to have black eyes, &c.

The hole in the middle of the iris is called the *pupil* of the eye. It is larger or smaller in proportion as the iris is shrunk more or less; for the iris will shrink or contract, a little like the muscles. The greater the light before the eye, the smaller is the pupil. When we are in the dark, it is very large, as if the iris shrunk back in order to let as many rays of light pass through the pupil, to the optic nerve, at the back part of the eye, as possible.

All the rest of the eye ball, besides the coverings which I have described, consists of a substance which I told you had some resemblance to the white of an egg, or that ropy but clear fluid in which the yolk swims. Anatomists, however, say that the greater part of it resembles melted glass, which I suppose few of you have seen; but as we have called the

eye a window, the comparison is a very happy one.

The edges of the iris or curtain, however, like a partition, divide this glassy liquor into two masses, connected only at the pupil. The part of it which is before the iris is called the *aqueous humor*, and that which is behind it, and which is many times the largest, the *vitreous humor*.

Just behind the iris, or rather exactly behind the pupil, is a small body, clear and transparent, like the rest of the vitreous humor, but much harder, and swimming, as it were, in its midst, without ever getting out of its place. It is called the *crystalline lens*. It is rounded or convex on both sides, and resembles two watch crystals, with their hollow or concave sides put together.

It is represented in the engraving, by a light spot, which you cannot fail to distinguish, near the fore part of the eye. There is a kind of disease of the eye, in which this lens turns whitish; and as the rays of light can no longer pass through it, the person becomes blind. The only way to cure it is for the surgeon to pass a slender needle through the side of the

eye, and push this hard, dry, dead body downwards, or to one side. This is often successful, and the process is attended with less pain than the extraction of a tooth.

Optic Nerve.—The optic nerve, which I mentioned as entering at the back part of the eye, expands or spreads itself as it enters, and this is called the *retina*. The rays of light, passing through the fore part of the eye,—1st, through the cornea, 2, the aqueous humor, (part of which lies before, and part behind the pupil,) 3, the crystalline lens, and 4, the vitreous humor—strike on the retina, and an image or picture of every object which is before the eye, is formed on the retina, inverted; that is, bottom upwards. Thus, if I am looking at a tree, there is a kind of image or shadow of that tree on the retina of my eye, with the bottom upward. *Why* everything which we look at does not appear to us *inverted*, rather than with the right end upwards, is not known.

The Tears.—Washing windows is often a slow and troublesome process, but there is a small gland, not unlike the gland which fur-

nishes the saliva or spittle, only much smaller, over the top of each eye, from which flows in small quantity, a clear liquid, and by means of the eyelids, operating as a cloth would do, this is carried over the whole surface of the eye, and keeps it constantly moist and clean. The dirty water is then carried off through a very narrow passage, and thrown out through a pipe or duct in the nose.

The little gland, over the eye, is called the lachrymal gland; the liquor which it furnishes to wash the eye, is called the tears; and the tube through which the tears escape into the nose, is called the lachrymal duct.

If this duct gets stopped, as not unfrequently happens, the tears overflow the eye and run down on the cheek; and a hollow piece of silver is sometimes furnished by the surgeon to insert in the duct from the eye to the nose, to keep it open and furnish a passage for the tears.

THE EYELIDS.—The eyelids are to guard the tender eye from injury in various ways.

One of their uses is to keep off the strong light of the sun. If our eyelids were cut off,

and if it did no other harm, I am sure we should soon become blind. Those people who let the full blaze of a candle, or lamp, or bright fire, shine on their eyes, do a great deal towards making themselves blind; but they are sometimes a great many years in finishing the work.

Another use of the eyelids is to ward off small bodies from the eyes, as sticks, chips, stones, &c. The power of the eye is wonderful in this respect. It will sometimes close so swiftly as to shut out an object which could not possibly have been seen; just as if it almost felt it coming before it arrived. It does not always close quickly enough, however; for blacksmiths, stone cutters, &c., sometimes have their eyes more or less injured.

The Eyebrows.—The eyebrows serve as a sort of defence to the eye, by catching a part of the dust that would otherwise fall into them. Perhaps they may have other uses than this, but I have not room to enlarge. I should like to describe the eyelashes, and mention their uses, and also speak of several other mem-

branes, vessels, &c., connected with this wonderful organ, but the limits of a work like this forbid.

Reflections.—I must not close this chapter without noticing the place in which the eye is situated. Some animals—as the snake, tortoise, &c.—have the eyes set in the side, or rather in the upper part of the head, precisely where they are wanted; for they have no occasion to look downward. In general, those animals that cannot move the eye without moving the whole body, have this organ more prominent, and more to the side.

But man, without moving his body at all, can move his head in such a manner that though the eyes are fixed in the front part of the head, and in a deep socket, he can yet look in every possible direction. All things considered, his eyes are as happily placed as those of any other known animal; and they are much better guarded from injury. Their deep bony socket, the high ridge around it, the eyebrows, the eyelids, the eyelashes, and lastly, reason to direct us and enable us to

avoid danger, all conspire to guard the "apple of the eye," as it has been called, with great care; and in this country it is comparatively seldom that we meet with a person, young or old, who has not both eyes perfect.

CHAPTER XIII.

THE COVERING.—THE DOORS.

The Ear. The Nose. The Mouth.

The doors of the house I live in are the mouth, ears, nose, &c. These I call doors for reasons which have already been given, and for others which will presently be seen.

The Ear.—Some account of this has been given in treating of the bones. The reader has already been told that it is made for the admission of sound; that if there were no ear, we could hear no sounds; and that a part of this curious organ lies deep in the bones of the head.

There are, in fact, two great divisions of the human ear; the external and the internal. The external ear is what we see in the living individual; consisting of a semi-circular portion,

spread out, the shape of which everybody knows; and a passage in the middle, leading into the head.

The external ear, which we see, is made of gristle or cartilage, covered with the skin. It is concave, for the collection of sound. Such is the curious structure of the eye, that the rays of light, from all directions, are collected into a very small point in the back part of it; and in like manner, such is the structure of the external ear, that sound is collected by it toward the passage, in the centre.

This passage is lined by a membrane just like the skin, except that it is a little thinner, the little bottles, or oil glands, are more numerous, and the oil which they furnish is more bitter. What is called the ear-wax is this oil, dried and accumulated in large quantities. Sometimes it has been known to accumulate in such hard masses and of such a size as to make people deaf. There was lately a case of this kind in Boston. Both ears were in this condition, but one was much worse off than the other.

This oil or wax is supposed to have been made bitter, to keep flies and other insects from getting into the ear. These insects dislike such

bitter substances. There is, however, less danger from having insects get into the ear than is commonly supposed; for when the ear-drum, or membrane of the tympanum, of which I have spoken in another place, is not ruptured, nothing can get into the head more than three quarters of an inch, and could easily be pushed or washed out.

If the ears are washed out well every day, and especially if they are syringed out often with weak soap-suds and water, we shall seldom have trouble, either from the collection of wax or from insects. Cleanliness is almost everything—not only in the case of the ear, but of all parts of the body.

Beyond the drum is a chamber, called by anatomists the cavity of the tympanum. In this cavity are the little bones which I have formerly described. Here also a small passage commences, which terminates near the back part of the nostrils. The use of this passage from the inside of the mouth to the internal ear is not very well known, but it is believed to be intended principally for the purpose of letting in air, in order that the pressure on both sides of the drum might be alike.

Some suppose that it enables us to hear a little through the mouth ; but this is not probable. If we hear at all through the mouth, it is in a degree scarcely worth mentioning.

Near the hinder part of this cavity of the tympanum there is also an opening into a collection of cells in the bone. The bones in which these cells are situated may be found quite prominent behind the ear. The use of the cells is not very well known.

Though the ear is to be considered a door of the human habitation, the passage in it, as we have seen, is usually closed by the ear drum. The door-way for everything except sound, would, therefore, be more properly through the mouth.

Sometimes—we know not how—the drum membrane gets broken. Men have been found, for example, who could force tobacco smoke, held in their mouth, out at their ears. This proves that the membrane in question must have had a hole in it. I do not know that this affects the hearing very much. It is true it requires us to be more cautious what we get into our ears, for if substances get beyond the ear drum quite into the cavity of

the tympanum, they will produce inflammation; and in the end, perhaps, cause deafness or death.

I wish I had room to tell you more about this cavity of the ear, and indeed about the whole organ of hearing; for it is a curious organ. But all I can say now, is a few words about the *labyrinth*.

This is a large cavity still deeper in the head than the foregoing, and, if possible, still more curious in its structure.

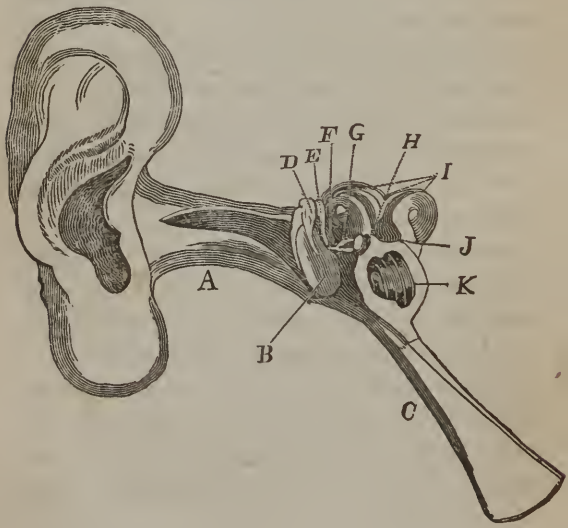
The middle part of the cavity is called the *vestibule*. It is somewhat oval in shape. At one end of it are three tubes, each of which is so bent or curved as to form almost a circle. They open into the vestibule, and are called semi-circular canals.

At the other end of the vestibule is a tube of a conical shape, but resembling, on its outside, the shell of a snail. It is called the *cochlea*. This also opens into the vestibule.

The little bones of the ear are connected with the ear drum on one side, and with the parts of the labyrinth just described on the other. The labyrinth, in all its parts, is most

intimately connected with the brain; and some of these very parts themselves seem almost like brain. They contain a tremulous jelly-like substance, among which those branches of the brain which we call the nerves of the ear are very thickly interspersed.

It is desirable in closing this chapter, to give you one view of the ear, both external and internal. Here it is.



In this engraving, A represents the tube or passage leading to the ear drum; B, the ear drum, or tympanum; C, the passage from the ear to the throat; D E F G, the little bones of the ear; I, the semi-circular canals in the ear; J, the vestibule; and K, the cochlea. H refers to a little opening.

THE NOSE.—This is a more important door of the human habitation than many suppose. All or nearly all animal and vegetable bodies are constantly sending off small particles, the quality of which, when they are received at the nose, in its natural state, can in general be easily detected.

This is undoubtedly one great purpose of this organ, and especially of its curious internal structure. For in order that we may detect the nature of the bodies whose particles the air is constantly full of, the inside of this organ of smell is very extensive.

1. The bones, in some places, project into the nose, like large but irregular shelves.

2. There is a hollow cavity in each cheek bone, which will hold about half an ounce, and

which has a communication with the inside of the nose.

3. There are also cavities in the forehead, at the top of the nose, between the eyes, which communicate, in like manner, with the cavity of the nose.

Over this extensive internal surface, viz. the whole inside of the nose, the surface of the projections or shelves, and the inside of the cavities in the cheek bone and forehead, a fine delicate membrane is spread; and over a great part of this membrane, little nerves are distributed, by means of which we smell. For I wish to say again, once for all, that we cannot have feeling or sensation, in the eye, in the ear, in the nose, or anywhere else, without the aid of these little branches of the brain, called nerves. And it helps us about smelling, that the particles of bodies in the air we breathe, are diffused over such a large surface as I have mentioned.

I have more than intimated that in a *natural* state of the organ of smell, it could detect all substances which were likely to prove injurious. This, though very probable, cannot be fully proved. Other animals, we know, can in general tell what will injure them, by its smell;

and we can do so in regard to very many things; and they can oftenest do this, whose smell is most perfect. There is, therefore, great reason for believing that, did we not early accustom our noses to the smell of strange mixtures—for almost everything we eat is some unnatural if not unwholesome mixture—we could distinguish by their smell those things which are hurtful; at least in most instances.

However this may be, one thing is certain; which is, that trained as we now are, in regard to eating and drinking, it would be very strange indeed if the sense of smell should long retain its original integrity.

The extensive cavity of the nose has another use besides favoring the sense of smell. If we hold our nose, and speak, or sing, we find the sound greatly altered, and rendered quite disagreeable. One intention of the nose, therefore, like those hollow bodies in some ancient buildings, placed over the head of the speaker, and called *sounding* boxes, is to modify and improve the voice.

How poorly the nose sometimes answers this purpose, is best seen in those individuals

who dry up the nasal membrane with snuff, or make the nose a chimney for tobacco smoke—purposes for which we may be very sure they were never designed by the Creator, and to which well informed people would not be apt to apply them.

THE MOUTH.—This is, in many respects, the more important door of the human frame. For if the nose should cease to perform its office, we could supply its place, in some measure, by the eye, the ears, and the touch. The same is true of the ear, and even of the eye. But if the mouth were to fail—if this door were closed forever—there is no substitute. We may indeed receive a part of the supplies necessary to our existence (I mean air) through the nose; but a far greater part could not be received even in this way; and our frame would soon decay, and mingle with its kindred dust.

I have never known but one instance in which an effectual substitute for the mouth was provided. Several years ago, a young Canadian by the name of Alexis St. Martin was wounded, in the army, by a ball which shot

away a part of the flesh of the side and stomach. When he recovered, an opening was left somewhat like the mouth of a purse, directly from his left side into the stomach. So complete was this artificial mouth, that though it was very tender, food and drink could be introduced into it through a pipe; and if care were used, it could be done without pain. The contents of the stomach—the fluid contents at least—which had been swallowed by the mouth, could also be taken out at any time.

I have seen Alexis once myself; and have witnessed the things which I state. But this is a solitary case; and I do not know that any other case of the kind ever existed or ever will exist again.

The particular structure of the mouth—curious as it is—is so well known, that it does not seem to require a particular description, under this head. When I come to speak of the apartments, and especially of the furniture and employments of the house I live in, I shall have occasion to say more about it. It was only necessary to mention it here as a part of the covering, and for the sake of method.

CHAPTER XIV.

APARTMENTS AND FURNITURE.

General Remarks. The External Ear. Chambers of the Nose. The Mouth, internally. The Salivary Glands. Passages to the Ear. The Chest. Cavity of the Lungs. The Food Pipe. The Stomach. The Intestines. Gall Bladder, &c. The Abdomen. The Apartment of the Circulation. Chambers of the Brain.

General Remarks.—There are two kinds of apartments in the house of the soul. One of these is connected with outside doors; the other is not. Both are numerous, and both are important. I will begin with a description of the former; and occasionally speak, as I go along, of some of the latter.

In many houses a broad space or hall extends through from the door in front to the

back side of the building. This space is not always either uniform or regular. Sometimes —and indeed usually—if the house has more than one story, it contains a stairway; and sometimes it includes a closet, or a room for other purposes. Doors also in the sides of this hall connect it with other apartments.

Now the house I live in is constructed very much on the same general plan, except that, as I told you in reference to the frame, there is no *square* work about it. The beauty of the internal parts of a common dwelling house depends very much on its straight lines, upright walls, and horizontal floors and ceilings; but the beauty of the habitation of the human soul consists, on the contrary, in curved lines. Not an apartment can be found, in good order, in which you can trace a single straight line.

But there is another difference which is still more essential. The same kind of covering which is applied to the house I live in, is also applied to form the covering—or perhaps you would say the lining—of the sides of the space or hall I have spoken of, as well as of all its apartments; except that it is thinner,

more neatly wrought, and without much pigment or paint. Whereas you know it is seldom, if ever, that you can see the inside of any part of a wooden house shingled or clapboarded. We should laugh outright, to see the walls of a beautiful parlor or bed-room shingled.

There is one more essential and important difference. The rooms in many dwellings are often partly or wholly empty ; or at least there is nothing in them except a small quantity of furniture and air. But except a few very small and not very important apartments, all the rooms of the house I live in are completely filled. Such a thing as empty space is hardly known there. The furniture, or whatever is in them, at all times completely fills them ; for when anything is removed from them, their walls are accustomed to shrink accordingly ; and when anything is introduced into them, these walls have the power of gradually yielding so as greatly to increase the capacity of the apartments.

It is true that the furniture, &c., in each room, does not so entirely fill it as not to leave place for air ; for as I have already said, all the

kind of rooms of which I am now treating, have communication with the open air, in such a way that the air, in small quantity, can, and probably does reach them; and much more of it would reach them, were they not so closely filled as to prevent its admittance.

But it is time for me to speak of these apartments with more particularity. I have already shown you that all the cavities, or passages in the human body which open to the air, such as the ears, nose, mouth, &c., are lined with a membrane almost exactly like the skin, only thinner. It has its thick layer, or real skin, on a thin cellular layer; then its soft thin layer of pigment or paint, if this has any existence beyond the commencement of the openings, say at the edge of the lips;* then, and lastly, its cuticle.

This membrane is not called skin, however, except on the surface. Its usual name is *mucous membrane*, because it everywhere *secretes* on its

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* Anatomists are not agreed on this point. The general opinion is, that this membrane which contains the color does not exist at all in the internal cavities of the body.

surface more or less of a substance which is called mucus.

External Ear.—The passage into the ear, as we have already seen, is lined with this membrane. But this passage or cavity is so small that it can hardly be called an apartment. The cavities connected with the nose are of much more consequence.

Chambers of the Nose.—These, as we have seen, are—1. The hollow but very irregular passage of the nose itself. 2. The cavity in each cheek bone. 3. The cavity in the forehead, or on each side of the root of the nose. All these cavities are *real* cavities; for they are situated in hollows in the bones, and therefore their sides cannot fall together and close up the space.

All these cavities, moreover, become in some cases the seat of painful diseases. The nose is subject to the polypus—a pear-shaped swelling with a narrow neck. This sometimes renders our breathing difficult; and if not extracted, has been known to go farther, and be-

come the means of destroying life. Even if it is extracted, it is very apt to grow again.

Painful diseases also occasionally arise in the cavity of the cheek. These are sometimes mistaken for tooth-ache. The extraction of the tooth which appears to cause the pain, unless its roots extend through, quite into the cavity, affords, in such cases, no permanent relief.

Some kinds of head-ache probably have their seat in the hollows of the frontal or forehead bone, near the root of the nose. A very common disease in sheep, is known to be produced by worms in these hollows. The dull, heavy pain so often felt over the eyes, especially when we have what is commonly called a cold in the head, may be owing to a slight inflammation of the membranes of this cavity.

People ought to be careful about smelling things which give them much pain. Probably the use of most of our smelling bottles is injurious, in the end, to the delicate lining of all these "rooms" connected with the nose. Snuff certainly is, and so is the smoking of tobacco, cigars and opium—so common in some countries.

"Naturalists say there is one species of maggot-fly that mistakes the odor of some kinds of snuff, for that of putrid substances, and deposits its eggs in it. In warm weather, therefore, it must be dangerous to take snuff which has been exposed to these insects; for the eggs sometimes hatch in two hours, and the most tremendous consequences might follow." *

THE MOUTH, INTERNALLY.—The mouth, of itself, is one of the apartments of the human body, and a very curious apartment too. When I spoke of it as one of the doors, I referred principally to the aperture formed by a cleft of the lips, or the external mouth; and not to the *internal*, or more important part.

In this chamber—the entrance chamber of the front door—we find the teeth, the tongue, the palate, and several little glands. This entrance chamber is larger than the hall or space beyond it. Doors also open from it into several other apartments.

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* See "Young Man's Guide," p. 191.

THE SALIVARY GLANDS.—The first of these doors are very small. They are on the inside of each cheek, nearly opposite to the smaller double teeth. They lead through a very narrow passage, scarcely bigger than a straw, to the chambers where a large part of the saliva or spittle is secreted or made, which is just back of the hindermost part of the jaw bone, and just below the ear.

These chambers are neither large nor regular. Indeed, they scarcely deserve the name of chambers, any more than do those in the upper part of the socket of the eye, of which I have already spoken, and which secrete the tears.

Under the tongue and partly before it, are the doors of passages, still shorter and smaller than those I have just mentioned, and leading to apartments of still less importance. They are, however, for the same purpose; that of secreting the saliva.

PASSAGES TO THE EAR.—Farther on, in the upper and back part of the mouth, are two doors of considerable size, connecting with the

chambers of the nose ; and in the same region begin the passages which lead to the middle cavity of the ear which has been already mentioned, called the tympanum. I have said enough about these various apartments in another place.

A little behind the roof of the tongue, is an opening, whose structure has a strong resemblance to what is usually called a *trap door*. It leads to the lungs or breathing apparatus, occupying a very large upper apartment of the body. This is one of the most curious parts of the human system. No real gate or door, set on hinges, and guarded by an active and intelligent porter, would better answer its intended purpose.

I have said that there is a strong resemblance here to a trap door. The passage to the lungs, where it commences, is a mere slit ; though it is true it very soon becomes larger. Over this slit is placed a lid or flap, not unlike the tongue in shape, but of course much smaller, which fits to the opening as exactly as ever a trap door was fitted to its door-way.

It is not usually shut, however, except when we attempt to swallow something. Then the

substance we swallow, and the motion of swallowing, press it down and close it tightly. And it is well that it is so; for if it were not, the substances which we swallow would often drop into the passage to which this trap door opens, and cause us great trouble.

THE CHEST.—Beyond the door, the passage greatly enlarges, and proceeds downwards into the chest, the large apartment which I have just mentioned. This apartment is one of the largest in the house I live in, and nearly fills the upper story. It is one of the kind which has no outer doors, neither is it connected with any other cavity or apartment. It is supported on all sides by strong bony walls; the breast bone in front, the back bone behind, and the ribs at the sides. Above, at the fore part of the neck, it is of course less guarded with bone; and at the bottom there are no bones at all. It is separated from the apartments of the second or lower story, by a strong skin or membrane called the *diaphragm* or midriff.

CAVITY OF THE LUNGS.—The trap door, of which I have spoken, does not lead directly into

this large apartment, but only into a bag or sack, called the lungs, which lies in it, and fills it; and is divided into two portions, one on the right side and the other on the left. The passage from the doorway at the top of the throat into the lungs, is at first considerably large, and may be both felt and seen at the top of the throat. It appears, at first view, to be a long bony tube, but it is not so. It is made of firm cartilage, almost as hard as bone. As soon, however, as it gets fairly within the cavity of the chest, it ceases to be cartilage, and becomes nothing more than common membrane.

The passage now divides into two, like the trunk of a tree when it divides into two branches. One of these smaller passages goes to the right side of the lungs, the other to the left. Soon each of these parts divide again; then those branches subdivide; and it is not long before the branches become as numerous as the limbs of the thickest tree top you ever saw; and indeed much more so. And what makes them appear thicker than they really are, is the ten thousand little cells, like innumerable small berries among the limbs of a tree or shrub, which are everywhere interspersed; for every one of

the smallest passages, into which the larger passages lead, terminates in a little hollow cell. Some of the cells are indeed larger than others, but they are all very minute, so much so that many anatomists formerly doubted their existence.

The most correct resemblance of these passages and cells or little rooms would, in my opinion, be a very thick branch of some shrub, very full of the minutest berries you can conceive of, and without leaves. But you must not forget to think of the shrub as *hollow* through all its branches and twigs quite into the cells, and as divested of its leaves.

This, however, you are to remember, will not give you a correct idea of the whole lungs, but only of the little tubes and cells for carrying and holding air.

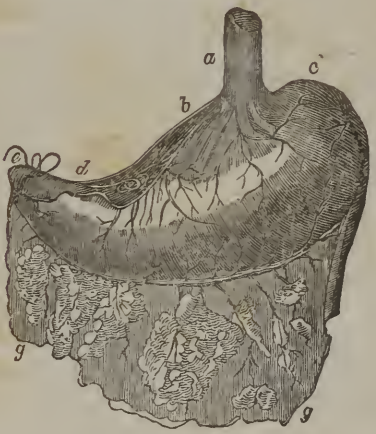
In order to make the shrub, in the case above mentioned, look like real lungs, I must cut the extremities of the twigs, till I bring the bush into the right shape; then I must interweave something like spiders' web or cotton among all its branches, &c., and thus fill up all the space; and lastly, I must cover the whole with a pale red, but very thin covering.

Thus you see that the trap door at the top of the throat, opens into a large passage which divides and subdivides almost without end; and leads into as many little rooms or cells as there are of its numerous subdivisions; and that this whole mass, the lungs, fills up one very large room which has no door or opening.

The Food Pipe.—The back part of the mouth, where the food pipe or passage to the stomach commences, is funnel-shaped; but the passage or food pipe itself is pretty regular in its shape. It proceeds along down near the back bone till it has fairly passed the apartment of the chest, and enters the borders of the great apartment below it, occupying the second or lower story of the building. When it reaches the confines of this apartment, the passage enlarges into a spacious saloon. This is the stomach.

The Stomach.—The human stomach somewhat resembles, in shape, the bag of the Scottish instrument of music called the bag-pipe. It lies directly across the body just under the edge of the ribs, and in such close contact with

the diaphragm or floor of the apartment which contains the lungs, that the latter seem to rest directly upon it. The place where the food pipe enters it is called the *cardiac orifice*, and the termination or outlet of this spacious saloon is called the *pylorus* or pyloric orifice. The meaning of the word cardiac is not of much consequence; the word pylorus will be explained hereafter.



In this representation of the human stomach, the letter *a* represents the lower part of the

gullet or food pipe, *c*, the left or large extremity, *d*, the end or small extremity, and *e*, the pylorus. The stomach of an adult will hold, when moderately stretched, about two or three pints.

THE INTESTINES.—Beyond the stomach, the passage through the house I live in, though exceedingly winding, is rather more uniform in its dimensions than it is before we arrive at the stomach. But even here the size varies. Immediately after leaving the stomach, the space, though at first rather large, rapidly diminishes, and becomes and remains small till we get more than three quarters of the way through, when it again enlarges, and continues enlarged to the extremity.

The distance from the mouth to the extremity, through all the windings of this avenue, varies somewhat in different persons; but may be set down as about six times the height of the individual.

GALL BLADDER.—Not far beyond the stomach is an opening or door leading through

a duct to the gall bladder and liver. The chambers of these two organs are little more spacious than those of the glands already spoken of which secrete the saliva. The gall bladder may be as large as a man's thumb, or sometimes larger. In the same neighborhood is the pancreas or sweet bread, between which and the main passage through the body there is also a communication.

Abdomen.—In this lower story of the house I live in—the *abdomen*—there are several other apartments besides those I have already described, some of which open externally, and others do not. But I must now describe another class of apartments:—those which do not have communication with the air.

One of these has already been mentioned: it is the cavity of the chest. Another is the cavity of the cranium, or bones of the head. Another still is in the central part of the brain or contents of the cranium. The last, but most curious and most important which I shall describe, is the great cavity of the circulation; I mean of the circulation of the blood.

Apartment of the Circulation.—This is a larger apartment than many would at first suppose. It must of course be large, to contain, as it does, twelve or fifteen quarts of blood. It is like the hollow channels of two great underground rivers, formed by the union of ten thousand thousand larger or smaller (but most of them very small) streams, running side by side with each other, but never intermingling their contents. As they have no communication with each other in their course, so they have no outlet—at least none of any considerable size.

To talk here about the circulation of blood, when my professed object is to describe a chamber, may to many seem out of place; but to me, it appears indispensable. For such is the irregularity of this circulatory apartment, that it is next to impossible to describe it, in any other way than by telling you something of its course and contents. But I will be very short.

You may first think of all these streams as if they were filled with blood; and afterward, as if emptied of their blood, and hollow. In

the latter case, if a quantity of liquid, such as water, or melted wax, or even blood, were thrown into the cavities of the heart by means of a syringe, and if considerable effort were made, the liquid thrown in would soon run into all the large and small branches of this hollow river channel, or apartment, and fill it entirely; and the amount it would contain, as I have before intimated, would be in an adult equal to three or four gallons. Or to make it perfectly plain to all, it would be equal to a common sized pail full.

Thus you see that though the apartment of the circulation is strangely irregular, it is nevertheless a very spacious apartment; almost if not quite equal to the whole cavity of the chest, in which the lungs and heart are placed; and not much inferior in point of size, to the cavity below it, or that of the abdomen.

But I must tell you here—for I can now do it—something more of that part of the circulatory apartment which lies in the heart itself, or in what may be called the little sea or lake into which all these subterranean rivers constantly pour their various crimson floods.

The heart has really four cavities in it, two on the right side and two on the left. The blood which has been sent out into all parts of the body through the arteries, returns to the first or upper part of the right side, and then passes through into the right ventricle. As soon as this ventricle is full, it contracts, and presses its contents, the blood, into a great artery, called the pulmonary artery, which carries it to all parts of the lungs, whence it comes back into the left side of the heart; first into the left auricle, and next into the left ventricle. From the latter it is pressed, when the heart contracts, into the great artery, or aorta, and sent all over the body.

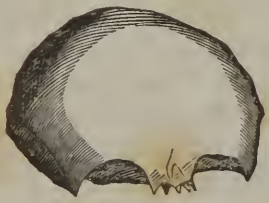
These four smaller cavities or chambers, taken together, hold, in an adult, about two or three ounces of blood; or something more than half a gill. The length of an adult heart, measured on the outside, is about five inches. We may say, in general terms, that it is about the size of a man's fist.

A great deal more might be said about the heart—its cavities, structure, motion, situation, &c., but I have said all that is necessary in

order to give a general idea of the circulatory apartment.

CHAMBERS OF THE BRAIN.—Before I describe these I shall be obliged to say something more about the brain itself, though I have partly described it at page 39.

Here is a picture of the bones of the cranium —those which hold the brain. It is the same picture which you saw at page 74, but for convenience' sake I have introduced it again in this place.



When I was a boy and heard about the brain, I used to wonder in what part of the head it was situated. I had seen the brain of several domestic animals, such as the ox, the calf, the swine, and the lamb; and as these

appear to occupy only a small part of the head, I concluded that the *human* brain did not. Some person, as ignorant as myself, told me that my brains lay in my forehead; and this opinion I grew up with. But since I became a man, I found out that they extend farther.

The color and general appearance of the human brain is not unlike those of domestic animals, but it is a great deal larger. Man has a larger brain, in proportion to his body, than almost any other known animal.

To give you a more accurate idea of its exact size, however, just take a piece of twine and tie it round your head from the bottom of the eye-brows or edge of the forehead to the nape of the neck, letting it come down close behind the root of the ear. Now all above this string, except the skull itself, and the skin, flesh, hair, &c., is brain: and the whole covering, bone, flesh, skin, &c., can hardly be more than half an inch thick, in the thickest part, and in some places scarce a quarter of an inch thick; so that there is a very considerable quantity of the brain, as you see. There is even a *little* brain below the

line of the string, but not much, unless you call that *brain* which runs down into the hollow cavity of the spine, like a large whitish cord, and which I have already told you is called the spinal marrow.

In the sides of the pile of bones called the spine, are holes all along from top to bottom. They are formed by notches in each vertebra, which when put together form holes. There are also six or seven pair of holes similar to these, through the sides of the strong bone below, on which the spine stands. Through each of these run large branches of the spinal marrow, called nerves. These branches or cords are whitish, like the marrow itself, and like the brain. Their number is about thirty on each side. They part into branches almost innumerable, and are distributed to nearly all parts of the body. Besides these thirty pairs, nine pairs more go out from the bottom of the brain itself, through holes in the cranium.

The nerves divide as minutely as do the arteries and veins. This is proved by the fact that we have feeling almost everywhere in us.

A wound with the point of the smallest needle gives us pain, but this could not be, unless there were nerves in the part which is wounded. I suppose they are so numerous that if there were any way of destroying all parts of the human body except the nerves, without in the slightest degree injuring or displacing the latter, they would present a large mass—whitish, indeed, and not quite so firm—but resembling, in shape, the complete and perfect living body. The arteries—the vessels which carry blood from the heart to all parts of the body—if all else were destroyed, would probably present the same appearance ; and so would the veins. This shows, in a most striking manner, that each of these parts of the frame must be very numerous.

There is however one important difference between the nerves and the blood vessels. The latter are all hollow tubes, but the nerves are not known to be so. The large ones certainly are not. Some have supposed that the little white pulpy threads or fibres of which they are all made up are hollow ; but this too is not very probable.

There are several curious apartments in the brain, but it is difficult for me to describe them in a small work like this. The whole brain, as I have already said, exactly fills up the hollow brain-case; and I might have added, that the spinal marrow completely fills the hollow of the spinal column.

One of the chambers in the interior of the brain was supposed by the philosopher Descartes to be the particular residence of the spiritual inhabitant. Now I will not stop to say what may have been the fact in the days of Descartes, nor to say how it may be with *all other* spiritual inhabitants of houses of clay, but for myself I can assure the reader with certainty that I do not exclusively reside there. I live in all parts of the brain, spinal marrow and nervous system; though I will not deny that the brain is my more special residence.

CHAPTER XV.

FURNITURE OF THE HOUSE, AND ITS USES.

The Blood. Preparing the Blood. Mastication or Chewing. Swallowing. A Trap Door. Digestion. Formation of Chyle. Lacteals. Absorbents. Materials for Blood. Nature of the Blood. Nature of Secretion. Motion of the Heart. Pulsation. Force of the Heart. Capillaries.

We come now to the furniture of the house I live in, and its various uses. This will make a long, but I trust an interesting chapter.

Here, however, our similitude begins to fail; for while the house I occupy, like all other houses, is liable to daily waste and decay, there is, in the human habitation, certain furniture—machinery perhaps I should say—by means of which, if properly managed, repairs are going

on equal, at least, to the waste. But in no ordinary dwelling can any such process be found. All dwellings can indeed be repaired, but it is usually by machinery without, and not within.

The habitation of the human soul is kept in repair partly by means of the rivers which run through the circulatory apartment. It was this fact that made it necessary for me to dwell so long upon this apartment in the previous chapter.

The Blood.—There is nothing in this part of the universe which so much resembles the economy of the human body, and the means by which its constant waste is supplied, and the whole kept in repair, as watering and supplying the face of the earth. Evaporation and the growth of plants and animals are constantly wasting or drying up the soil; but there are numerous hidden streams, some of them very small, that wind their way almost everywhere, and continually furnish new moisture.

It is true, there are also large streams which appear on the surface, unlike the surface of

the human body; neither is it to be forgotten that the earth is watered, in part, directly from the atmosphere.

Still there is a striking resemblance between the two great processes*—the one to repair constantly the wants of a world; the other, to supply the wants and repair the waste, &c. of what, for the sake of its near relation to its celestial habitant, is worth far more than any known globe.

Preparing the Blood.—But how is this blood, in its ten thousand thousand crimson streams, prepared and supplied to the human body? for it must be first *made* before it can be supplied. It is a most curious and indeed wonderful process, and one which demands a particular description.

Mastication, or Chewing.—I have already told you about the teeth, their number, their uses, &c. I am now ready to say that

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*Man, in this point of view, more than in any other, may justly be called a Microcosm.

they are principally designed for breaking down and grinding the material of which the blood is to be made. For the great Author of our frames has so ordered it, that as fast as our systems waste, a feeling arises in us which we call hunger; and we take much pleasure in gratifying that hunger. But in order to gratify hunger properly, there is a work for the teeth to perform, of which I have just spoken.

But while the teeth are breaking in pieces our food, the salivary glands, described in another place, are continually secreting and pouring through small tubes into the mouth, a quantity of saliva just sufficient to moisten it, and render it somewhat like pulp. There are also other little glands, under the tongue, which assist in the work.

Swallowing.—When the food is beaten fine and moistened sufficiently, it is gathered together upon the tongue, and by a curious series of movements, which I have not room in a work like this to explain, it is pushed along beyond the root of the tongue, to the top of the gullet, or food pipe, whence it is conveyed downward into the stomach.

In its passage it goes directly over the trap door of which I have already spoken; and if we were not careful, would sometimes drop into it. If we laugh, or cough, or speak, or sing, while the food is passing by this opening, there is very great danger.

Trap Door.—It is true that this door usually closes when anything approaches, almost as quickly as I formerly told you the eye does when anything approaches that. But it is also true that, as it is in the case of the eye, it does not always close quite soon enough, and substances sometimes actually fall in. When they do, they produce irritation and tickling, and induce us to cough, which occasionally throws up the offending substance. When it does not, the coughing frequently soon subsides, and if the substance is nothing harder than a piece of bread, it dissolves slowly, and gets away; but if it is something harder, as a piece of a chesnut or a kernel of corn, it usually causes trouble; and, unless the surgeon can remove it by cutting open the windpipe, ends in death.

While writing this chapter, I have read in the Boston Medical and Surgical Journal, of

a little girl, five years old, who, in playing with a brass nail, suffered it to get into her windpipe. It produced a little coughing, and then all was over; and the parents and friends thought all was well. But more than a year afterward, on taking a cold, a bad cough, with hectic fever, night sweats, and bleeding at the lungs, came on, and she died of a quick consumption. On opening her body, the brass nail was found in her lungs.

I hope every young person who reads this account will avoid holding such things in his mouth, as well as all talking and laughing while eating; for it is at least dangerous, and may prove fatal to him.

When the food is fairly beyond the tongue and the little trap door, it goes into the top of the food pipe, as into a sort of funnel top. Below, this pipe is smaller; but if we eat and swallow slowly, not so small as to hinder the food from passing. But if we do not half chew our food, or if we swallow it too rapidly, it sometimes sticks in this passage, and causes great trouble. I have known persons come very near dying, by having a large piece

of meat, or some other hard or unchewed substance, get lodged here; and it was only with the help of the surgeon, that their lives were saved.

Digestion.—The food, however, at length arrives in the stomach. Here, after remaining a short time, it gradually softens still more than before, and becomes a grayish or whitish pulp, called chyme. The formation of this chyme is greatly hastened by a fluid called the gastric juice. This does not come a long way through pipes, like the saliva, but seems to ooze out of the inside of the stomach, in large drops, as you have seen the drops of water or sweat from the forehead of a laboring man, in a hot day.

When the outside of the mass in the stomach becomes soft, it is slowly conveyed, by a curious motion of this organ, from its left towards its right end, to what I have already told you is called the pylorus. By the pylorus is meant the door or outer gate of the stomach, or as some call it, the door keeper. It may well be called a door keeper, for it really seems to exercise

a sort of choice. If anything comes along which is not proper to go into the system, or not yet fit to make blood, it does not for some time suffer it to pass; though after the substance has repeated its efforts to pass a great many times, it appears to yield, as if to importunity. True chyme, made of good and proper materials, it never refuses, but suffers it to go through at once into the portion of the intestines next to the stomach, called the *duodenum*.

Formation of Chyme.—Here, in the duodenum, it becomes a still more perfect chyme, and is gradually mixed with a bitter liquor, called *bile*, coming through a small pipe from the liver, and with a liquor resembling saliva, coming from the *pancreas*, or, as it is called, sweet bread. Being mixed with these liquors, some of it slowly passes along, and spreads itself over nearly the whole internal surface of the intestines. It is always in greatest abundance, however, in the duodenum, and a few feet of the intestines next to it.

Lacteals.—Now there is in the human body a set of little vessels called lacteals, which begin in great numbers, as if by their roots, in the sides of the intestines, and gradually uniting as they proceed along, they all at length come together into one principal trunk or large pipe, which might be compared to the trunk or stem of a tree. These vessels—or their roots—seem to begin on the inside of the duodenum and other intestines, with open or funnel-shaped mouths, with which they suck up the finer or better parts of the liquid there, and which, during the operation of being taken up, is changed into a pearly colored or milky fluid, called *chyle*.

This last, after being taken up, is conveyed along in the small vessels it begins with, till they unite with others, like small streams with larger ones. These again unite with those which are still larger, until they at last meet in a grand trunk or receptacle.

From this receptacle or reservoir, one or more pipes or ducts go out to carry the chyle which it contains up towards the top of the left shoulder. Here is a great vein, which

brings back the blood from the left arm, and pours it into the heart; and into this vein the chyle is poured, and mixed with the blood, with which it immediately descends into the heart, whence it also goes directly to the lungs.

Absorbents.—There is also another set of vessels, found almost all over the human body, which unite, by their tributary streams, to form this mass of liquid which is thus poured into the veins. They are called *absorbents*. They absorb or suck up any substance not wanted in one place, and carry it back into the blood, to be sent round again, to be used where it is really wanted, or else to be expelled from the body. The liquid which is thus found in these vessels is called *lymph*. The lymph is of a pale red color, but wholly different from blood. Besides having the general name of absorbents, these vessels are sometimes called lymphatics.

I have said that the chyle is pearl colored; but that depends generally on the kind of material from which it is prepared. If that consists partly or wholly of flesh, the chyle is more or less milky in its appearance; but if

the food is wholly vegetable, the chyle is of a fine pearl color.

The chyle, in its pure state, is just like the blood, except in color. The little globules, (small round bodies,) which swim in the blood, and give color to it, are numerous in the chyle; but instead of being red, as in the blood, they are white. I have said that the chyle, in its nature, is like the blood. Of the nature of the latter, I shall have occasion to say more presently.

Whether the chyle is changed to a red color as soon as it is mixed with the blood, or whether the change does not take place till it has passed with it through the lungs, we can better judge, perhaps, when we come to speak of the blood, and the changes it undergoes in those organs.

Having thus traced the food, or raw material, through the whole of a most wonderful manufacturing process, (which, by the way, we call digestion,) till chyle, and perhaps blood is formed from it, it may be well to pause and consider, for a few moments, the different materials from which this most important fluid is prepared.

MATERIALS FOR BLOOD.—The great Creator has so formed this wonderful apparatus, that it has the power of forming chyle from almost every substance, either in the animal or vegetable kingdom. Some make more, others less; some make it of excellent quality, others of a quality very inferior. From some, it is formed very rapidly; from others, very slowly. Some things, in the process of digestion, give out a great deal of heat; others, very little. Lastly, some produce great excitement and disturbance of the stomach and other organs, while others produce almost no disturbance at all.

As a general rule, those things which produce the least disturbance of the digestive organs, and of the other organs of the body, as well as the least heat, make the best chyle, and the best blood; and are, of course, the best adapted to our use. It must be observed, however, that much depends upon habit; and that a substance which is naturally rather inferior to another may, by habit, be rendered for a time somewhat more useful.

Among the best things to subject to the process of digestion are, bread made of wheat

flour unbolted, from one to three or four days old; bread made of corn meal and rye meal, either separate or mixed; bread or puddings made of rice, sago, tapioca or corn meal; potatoes, apples, pears, peas, beans, &c. For infants who have no teeth, milk, as it is well known, forms the best chyle and blood. For adults, a tolerable sort of chyle may be formed of plain but lean meats, fish, milk and eggs; and an inferior sort, of butter, cheese, cakes, pies, hot bread, beets, turnips, onions, &c.

All these substances may be better or worse, according as they are more or less broken and ground down with the teeth, and mixed with the saliva; and according to their quantity. The best of them, if not well masticated, make but an inferior sort of blood; and the worse, if well masticated, make chyle and blood which answers, in some good degree, the purposes of health. So of quantity: those which are even excellent in their nature, are not so good, if taken in excessive quantity.

Spirit makes no chyle or blood at all; wine, cider, ale, beer, coffee and tea, very little, unless milk, sugar, molasses, or something of the kind is mixed with them. Besides this,

they contain more or less of substances which not only do no good, but are positively hurtful. Even water can hardly be said to make either chyle or blood; but then it quenches our thirst, and answers many important and even indispensable purposes.

I am now to tell you about the blood;—first, what it is; secondly, its uses; thirdly, how it is kept in a good and healthy condition.

NATURE OF THE BLOOD.—If we open a vein with a lancet—as you know physicians sometimes do—and draw out a quantity of blood into a bowl, or any other vessel, and let it stand in the open air, it soon begins to clot or thicken, or, as it is usually called, *coagulate*.

From the surface of this coagulated part, a yellowish watery fluid oozes out, in numerous small drops, which gradually increase and unite, till, in a short time, there is more of this thin liquid than there is of the thicker coagulated part. This watery part is called the *serum*.

If we take the coagulated part of the blood, and wash it thoroughly, though carefully, we may divest it of nearly all its coloring matter,

and leave it white. This white substance is called *fibrine*, and strongly resembles the fibrous or thread-like substance of which I have already told you the muscles are formed.

The coloring matter, which we wash out, consists of small round or *globular* particles, which, before the blood coagulates, float in it; but, in the act of coagulation, become entangled in the fibrine. You have also been informed, in another place, that these globules exist and float in the same way in the chyle, before it mixes with the blood. In the chyle, however, they are colorless.

What gives the color to these globules in the blood is unknown. Some suppose it is the iron, or rather phosphate of iron. Phosphate of iron, it is well known, exists in the blood, in small quantity. Dr. Good thinks there is about three ounces in an adult, and that there is, of course, about enough in forty men to make a ploughshare.

I ought also to mention that sulphur is found by chemists in the blood; but they do not tell us in what proportion.

Thus we see that the three principal ingredients of the blood are the coloring matter, the

fibrine, and the serum. The serum is principally albumen and water; though it also contains, in small proportion, besides sulphur and iron, a great variety of substances, especially salts. Albumen is a substance which you may consider as resembling the white of an egg; for the latter is almost wholly composed of it.

USES OF THE BLOOD.—All parts of the human body, whether solid or fluid, and whatever may be their appearance or structure, are formed from the blood. I have told you how this fluid is sent out by the heart to all parts of the system, even to the bones. I have also said a few words about the saliva, and the gastric juice, and the bile, and have called them secretions.

It may be necessary to observe, in this place, that by the word *secretion*, as used in this book, is meant something formed from the blood. Not only the saliva, the tears, the gastric juice, the pancreatic fluid, and the bile are secretions, but the mucus which is everywhere found in the mucous membranes of the body, the water in the brain, the lungs, &c. In short, wherever you find water or anything

else, inside of the body, except in the intestines or the bladder, you may be pretty sure it is formed from the blood.

You will perhaps ask how it is formed. Sometimes it is by means of glands, larger or smaller; sometimes without them. A gland is a soft body, full of vessels—arteries, veins and absorbents. These vessels seem so numerous that one might be led to think the gland was wholly made up of them. Here is a picture of the vessels of the kidneys, as they would appear if a slice of this organ were carefully viewed, after the blood had been wiped away.

The kidney, however, is not so good a specimen of the nature of a gland as the liver would be. The larger glands of the human body are the liver, the spleen, the pancreas, the salivary glands, the lachrymal glands, &c. Besides these, there are small glands almost innumerable. The cerumen of the ear, and the oil of the skin, of which I have already spoken, are secreted by little glands.

The lymphatic or absorbent vessels are everywhere connected, in their passage through the body, with little glands. Some of these are larger, some smaller; and most of them are very small indeed. Those little swellings called *kernels*, which sometimes appear in the armpit or groin, or in the sides of the neck, are nothing but inflamed lymphatic glands.

All these glands, (except the lymphatic glands, whose use is unknown,) secrete something; and the material for secreting anything from is the blood, sent to them from the heart, into their ten thousand little vessels.

Nature of Secretion.—I have already observed that some of the liquids, &c. of the

human body seem to be secreted without the help of glands. They appear to be made directly from the blood vessels. How, we do not know. Perhaps they ooze through the sides of the vessels.

Here, perhaps, in the vessel, is blood; there, outside of it, but not a hair's breadth from it, is gastric juice, or some other entirely new substance. Here is simple chyme or chyle; there, at the distance of a hair's breadth, is chyle or blood. Here is chyme or chyle made of common food, with no sulphur, or iron, or nitrogen in it; there, perhaps not the twelfth part of an inch distant, is a fluid made from this very liquid, containing nitrogen, sulphur and iron!

By what secret laws of the Creator have these little vessels this wonderful power? By what mysterious process can they change—in the twinkling of an eye—a bland milky substance, made from simple bread, or milk, or potatoes, into iron or sulphur? But so it is. Well, indeed, might David the Psalmist express wonder.

Not only the liquid parts, but the solid parts too, are made from the blood. The very bones themselves, at first gelatine, are gradually made into bone, by means of the blood in its little vessels. First a particle of gelatine is taken away, by the absorbents; then comes along a particle of blood, or something that the blood contains, and stops in its place, and so on.

These particles, which are thus taken out to form bone in the place of gelatine, are many of them lime, or phosphate of lime, or at least something which makes lime, before it can become bone. Who directs the little particles of lime to the places where they are wanted? Who tells them to stop at the bones, and not before?

The power of the system to take out from the blood what is wanted for its growth and support, is aptly shown by Dr. Edwards.* He had been speaking of the wonderful distribution

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* See the Eighth Report of the American Temperance Society, page 11.

of the blood, in the little arteries, to every part of the body, when he thus adds:

"Along on the lines of these tubes or canals, (the arteries,) through which the blood, with all its treasures, flows, God has provided a vast multitude of little organs or waiters, whose office is, each one to take out of the blood, as it comes along, that kind and quantity of nourishment which it needs for its own support, and also for the support of that part of the body which is committed to its care. And although exceedingly minute and delicate, they are endowed by their Creator with the wonderful power of doing this, and also of abstaining from, or of expelling and throwing back into the common mass, what is unsuitable, or what they do not want, to be carried to some other place, where it may be needed; or if it is not needed anywhere, and is good for nothing, to be thrown out of the body as a nuisance.

"For instance, the organs placed at the ends of the fingers, when the blood comes there, take out of it what they need for their support, and also what is needed to make fin-

ger nails; while they will cautiously abstain from and repel that which will only make hair, and let it go on to the head. And the organs on the head carefully take out that which they need for their support, and also that which will make hair, or, in common language, cause it to grow; while they will cautiously abstain from taking that which is good for nothing except to make eyeballs, and let it go to the eyes, and will even help it on. And the organs about the eyes will take that, and work it up into eyes, or cause them to grow. And so throughout the whole."

Every one sees that there must be a constant waste in every part of the system. It is impossible but that the friction—the "wear and tear" of hundreds of muscles and tendons, and thousands of rapid streams—should gradually produce an effect, let the parts be ever so hard. A continual dropping will wear away a rock.

Now the blood not only carries out little atoms or particles to make all parts of the body grow, and to replace the atoms that are

worn off by friction in our motions, but it also takes away the worn out and good for nothing particles, and carries them out of the body. It is true they are taken up by the absorbents in the first place; but then the absorbents carry them to the blood, and empty them into it, which amounts to the same thing. In this way, as you may easily see, the blood is liable to lose its purity and excellence, since it is constantly giving out good particles, and receiving bad ones.*

Motion of the Heart.—The heart is kept in motion, we know not how; nor can the wisest anatomist or physiologist in the world tell us. We know that the lungs have

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* The manner in which the bad or waste particles are removed from the system is very curious. The kidneys seem to be a sort of sieve or filter; with this difference, however, that while a sieve permits only the finest and best parts to pass through it, the kidneys filter out the worse or coarser parts. These are carried in two pipes called *ureters*, to the bladder, whence they are conveyed immediately out of the system.

something to do in the case ;and when once set a-going, we can form some idea of what keeps it going; but after all, the real causes of the continued motion of either the heart or the lungs is a great mystery.

You are probably aware that you can feel the motion of the heart, if you will only lay your hand on your left side, near the lower ribs. This important organ—not larger than a man's fist, and strong and muscular—is situated slanting, or obliquely, as you see in the following engraving. It is represented nearly in the position in which my heart would appear, if you could stand before me this moment, and see it just as it now is, in full motion. I mean, its position is just what it would then be. In other respects, it would appear differently, especially in its connections; for the vessels which go to it and come from it are here represented as cut off.

On this cut *o* and *q* show the stumps of the two great veins which bring back the blood that had been sent to all parts of the body by the arteries. There are, however, one or two more rather large veins that bring back blood. These you see at *p*. The right auricle is at *n*; *b* is the right ventricle; *k* represents the pulmonary artery through which the blood is sent

to be changed in the lungs; *l l* are the right and left branches of this artery; *m m* show the great veins which bring back the blood from the lungs into the left auricle; *a*, the left ventricle; *c e f*, the great aorta, through which blood is sent out to all parts of the body; and *g h i*, the branches of this artery which carry blood to the neck, head and arms. The little arrows point always in the direction in which the blood runs.

But I must explain to you, a little more fully, the motion of the heart. The blood which returns from the lungs, through *m m*, and that which returns from all the rest of the body through *o p q*, enters both the right and left auricles at the same instant, and also in the same instant flows through these auricles into the two ventricles.

I ought before now to have told you that there is a strong partition between the right and left sides of the heart, so that the right auricle and right ventricle, with their blood brought back from the veins, can have nothing to do with the blood in the left auricle and left ventricle. It is indeed as if there were two

hearts placed side by side, and closely pressed together;—and in some animals, I believe there really are two.

Both the hearts however fill, as we have already seen, in the same instant. Now let us suppose them filled. What is next to be done? The heart contracts—shrinks—and compresses the blood with as much force as a strong man could compress it with his hand. But suppose you held in your hand a fleshy sack of blood that contained two or three ounces, with little hollow branches, that parted into ten thousand more into which the blood could flow, but could not get out of their sides or extremities. Suppose them now all full, and the sack full, too. If you press the sack hard with your hand, what will happen? Why, the blood, you will tell me, will go out of it into the branches. It will; but it will be as likely to go into one as another, provided it is equally large.

But there is another difficulty. As soon as I cease to press the sack, and the blood has an opportunity to do so, it will run back into it again. So you may perhaps, at first view,

suppose the heart would do. As soon as it should cease to contract, and begins to relax so that its cavities or chambers would hold just as much as they did before, the blood would run back into it. Why should it not?—No motion like that in our bodies would ever, in this way, be produced.

I have told you what one might naturally think who knew nothing about the circulation. But let us see for a moment what the facts are.

When the two auricles, one on each side of the heart, are full of blood, they contract at the same time and push the blood into the two ventricles. If you ask why this blood is not just as likely to go back into the veins again, when the auricles contract, as to go into the ventricles, I will give you two reasons. First, the veins are already full, and the mass of blood in them is flowing onward and pressing towards the auricles; and to force the blood back into them would be somewhat like pushing it up hill. But secondly, there are little clappers or valves, as they are called, in the sides of the veins, which, like so many small swinging doors, hang down against the sides of

the veins so long as the blood in them is running towards the auricles. But as soon as the auricles contract and the blood attempts to get back by the way it came, the valves spread out and form a kind of floor or partition which obstructs it.

These valves, by the way, are found in the larger veins all over the body; and now comes the reason why the blood can run up hill. The pressure in the veins is all the while diminishing, as you may easily see, on the side towards the heart, even though it is the up hill side; and as the arteries, at their extremities, are all the while pouring their blood into them, the pressure must be as constantly and certainly increasing on the other side. Besides this *general* pressure, there is also *local* pressure. The veins lie, most of them, in the skin, or among the muscles, or among parts that are performing some sort of motion. This motion must push the blood in one direction or another. But as the valves prevent its going back, the pressure is hard enough to make it go slowly up hill; and thus it moves on and on, till it finds its way to the heart.

But this is a digression, though it is a necessary one. I will now go back and proceed to describe the motion of the heart.

We have seen how it is that the blood gets out of the auricles into the ventricles, and why it goes into the ventricles rather than backward into the veins. Now the ventricles both contract; and as was the case with the two auricles, they both contract in the same instant. This contraction pushes their blood into the arteries, as I have before told you. The right ventricle pushes its blood into the pulmonary artery, whence it goes to the lungs; and the left ventricle pushes its blood into the great aorta, through which it goes to every part of the body.

Why does not the blood, when the ventricle contracts, go back into the auricle? Because there are valves between them which immediately spread out, like so many flaps or clappers, and form a sort of partition or floor, as the valves do in the veins, and prevent it. They do not, it is true, prevent every drop of it from returning. A very small quantity gets back, but none worth mentioning.

It is the contraction of the ventricles, which I have described, that causes the motion of the heart, and which is felt so plainly on the outside of our bodies. It takes place in an adult male, in good health, about once a second; in females, it is rather more frequent. It is most frequent, both in males and females, at birth; and diminishes in frequency till we come to middle age.

Pulsation.—This beating of the heart, as the blood is pushed from it into the arteries, seems to be felt in the large arteries all over the body. I say *seems* to be; but the subject is not well understood. We only know that if we lay our finger on an artery at the wrist, or in the ankle, or any other extreme part of the body—feel the pulse, as it is called—this beating in the extremities corresponds exactly with the beating of the heart.

Force of the Heart.—The force with which the ventricles press the blood to push it out of the heart has been variously estimated. Some reckon it at only a few ounces; others

much more, and some 180,000 pounds. The truth is that it presses very hard, with a force apparently equal if not superior to that of the gripe of a strong man with his fist. But it does not press with a force equal to thousands of pounds, nor even hundreds. I suspect it may be, in an adult, from 20 to 30 pounds.

One reason why anatomists have made such strange calculations is, that they could not conceive how the blood could otherwise be carried so swiftly to all parts of the system. The distance it has to go in some instances is great, for the arteries are very crooked. But they seemed to forget that by the curious structure we have mentioned, the veins were all the while getting empty, and a sort of vacuum forming in their cavities, into which the blood would naturally* rush from the arteries, so that the pressure or rather the resistance of the latter to the contents of the heart would be constantly diminishing, and thus there would be a tendency to a regular current of the blood.

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* It is said—and with some truth—that nature abhors a vacuum.

Capillaries.—They appear to forget also the structure and nature of the little arteries—sometimes called *capillaries*—found in such numbers in the skin, in the muscles, and indeed everywhere in the body. The truth is, that the coats of these little vessels are muscular, and it is a pretty well established fact that they have the power of drawing the blood from the heart. Dr. Smith, late an eminent professor of Surgery in Yale College, thought that these capillary vessels did almost all the work; the heart doing very little.

Others too have thought the same. They viewed them, something in the light of little pumps, all over the body, that were continually pumping up the blood from the deep well of the heart to the extremities of the remotest chambers of the body. You may form some idea of their meaning, by thinking of the Astor House in New York, and other public houses built on the same plan, where water is carried by means of pumps and other machinery to every room in the house, even to the highest story and the remotest chambers.

The truth here—as almost always happens—falls between extremes. The heart really

pushes the blood with considerable force; and the muscular capillaries, at the same time, act in a slight degree like little pumps. Then the vacuum I have spoken of has some influence; and there may be other causes in operation which I have not mentioned. The whole process of circulation is wonderful, and it requires a large volume to illustrate and explain it fully.

CHAPTER XVI.

FURNITURE, AND ITS USES—CONTINUED.

Purifying the Blood. The Lungs. Capacity of the Lungs. Breathing. Uses of Breathing. Nature of the Air. Breathing Air twice. Ventilation. Free motion of the Lungs. Tight Lacing.

WE are now prepared to enter upon another subject—the study of the process by which the purity of the blood is promoted, in defiance of many causes which are continually in operation to render it impure.

PURIFYING THE BLOOD.—This is done by means of air. But how is air to be introduced into the human body? Can we eat it? Can we drink it? Can it enter by means of the eyes, or the ears, or the nose? Not in either way exactly. It can indeed enter into the

nose, but without some other machinery, it would go no farther than the throat, before it must return or pass out at the mouth. A little, it is true, is swallowed, both in our food and drink; but the quantity is not very considerable.

There is air, moreover, in every part of the body; if there were not, we should soon be crushed. The atmosphere in which we live presses on us with a tremendous force, equal, it is said, in a middling sized man, to about 32,000 pounds. But as there is air in us, in all our solids and fluids, which presses outward while the atmosphere presses in the other direction, we do not perceive it.

But when I said the blood must be purified by the air, I meant in a manner much more rapid and effectual than could be done by its gradual introduction, and its circulation in the vessels.

The Lungs.—The house I live in contains something like a great bellows, by whose curious operation the blood is cleansed and purified. It is contained in the upper story, and fills

nearly the whole of it, leaving only a small chamber at one side for the heart. It blows its blasts at the rate of twenty or twenty-five a minute in an adult—and at a greater rate still in children—and continues them, whether we sleep or wake, as long as we live. I refer, as you will readily know, to the lungs.

I have already spoken briefly of the lungs. I have told you about the windpipe, which leads by its various branches to the ten thousand little cells within; and I have told you that all these cells were lined by mucous membrane, a membrane constructed like the skin, though thicker. But I believe I have not yet told you how much air these chambers of the human body will hold, nor how great are the superficial contents of the membrane on which the air is spread to be purified.

So numerous are the pipes and cells in the lungs, that it is commonly thought the extent of the mucous membrane which lines them must be equal, at least, to the extent of the skin. This is, in a middling sized adult, about fifteen square feet. Over all this surface the fresh air which we breathe may circulate and

fulfil its office in effecting that change in the blood of which I am to speak presently.

Capacity of the Lungs.—As to the quantity of air which the lungs will hold, it is very differently estimated. Many anatomists think it about 200 cubic inches, or three quarts, in the adult male; but I think there must be a mistake in their calculations, and that it cannot exceed two quarts.

When we breathe out, or *expire*, as it is called, we do not expel all the air actually in our lungs, but only a small part of it. Of course when we *inspire*, we merely introduce air enough to supply the place of what was before expelled.* The amount which we draw or inspire at each breath, (I speak of an adult still,) is thought to be about forty cubic inches, or over a pint; but I think this estimate also too high. Females, with lungs somewhat

* It may be well to say here, that while the process of inhaling air is called *inspiration* and that of expelling it *expiration*, the whole process of breathing is called *respiration*.

smaller than males, inspire a still smaller quantity, and children a quantity smaller still.

Breathing.—But how is the process of breathing performed? To understand this, it is necessary to revert once more to the structure of the frame-work of the human system.

The ribs, though fastened to the spine or back bone, are not so firmly fixed but what they admit of considerable motion. This motion is very curious, and somewhat difficult to describe. I can only say that it is of such a nature, if unconfined and unrestrained, as to enlarge the cavity of the chest when we inspire, and to diminish it when we expire.

This motion of the ribs is caused, in part, by the shortening or contracting of the muscles about the chest. Of these, there are two between every two ribs; and as there are, on both sides, twenty-four ribs, there are forty-four of these muscles concerned in moving the "bellows," every time I wish to breathe. In addition to these, there are nearly one hundred others, that have more or less concern in this matter.

An adult, generally, has from twenty to twenty-five of these inspirations in a minute, as I have already observed. When we exercise violently, as in running, the motion is more rapid. So it is in childhood, and sometimes in a fever. When the lungs move faster, the heart beats faster too, in the same proportion; the breathing and the contractions of the heart always bearing an exact proportion to each other.

Now what is the object of all this motion? For what purpose is a pint of air drawn into the lungs, and spread over fifteen square feet of internal surface, every three seconds, and another pint withdrawn from them as often? This I can, in part, tell you.

Uses of Breathing.—In its healthy natural state, before it is sent out into all parts of the body, the blood is composed of carbon, oxygen, nitrogen and hydrogen. Of one hundred parts of blood, fifty-three are carbon, twenty-four oxygen, sixteen nitrogen, and seven hydrogen.

But when it has been circulated all over the body, and has returned through the veins to

the right auricle and ventricle of the heart, its properties become greatly changed. It is now of a deep purple hue, and has hence often been called black blood.

In this state, it is found to be loaded with too great a proportion of carbon ; and this, too, notwithstanding what has been done by the skin ; for it is a most striking fact, that this very work of purifying the blood, of which I am about to speak as taking place in the lungs, takes place in a small degree all over the surface of the body. Still it does not complete the work, and the blood still comes from the heart through the pulmonary artery to the lungs in its impure, purple or black state—not only overloaded with carbon, but mixed with such other noxious ingredients as render it unfit for the use of the organs where it travels, in forming their various parts, secretions, &c. It also brings back with it—at least a few hours after every meal—a mass of chyle just mixed with the blood, which probably needs a change in the lungs, before it is fit to become blood, and afford nourishment to the system.

Arrived in the lungs, it is spread, almost immediately, over the vast space which is af-

forded by their numerous cells, and thus exposed to the atmospheric air. This produces a most surprising change; and the blood is now sent back into the left auricle and ventricle of the heart, to be distributed all over the system, in a renovated (renewed) state. Its color is changed to a bright scarlet; it has lost its superabundance of carbon, and its other bad qualities, and it has acquired new life and new spirit.

About the precise nature of this change—whether the blood takes in something from the air, or whether the air takes something away from the blood, there has hitherto been a great difference of opinion; and even now the point is not wholly settled. It is sufficient for us, in a book like this, to know that a change does take place, and what its results are, in regard to health.

Nature of the Air.—But I must not pass over this part of my subject, without mentioning the changes which take place in the air which, in the lungs, comes in such close contact with the blood. This air, in its natu-

ral and most fit state for breathing, consists of about 80 parts of nitrogen gas, and 20 of oxygen gas, or vital air; though some say there is always a little carbonic acid gas mixed with it, even in its purest or healthiest state. But no sooner is it breathed over in the lungs—even once—than the oxygen is greatly diminished, and the carbonic acid gas greatly increased. If we breathe the same air over twice or three times, the carbonic acid becomes still more abundant, while the oxygen as rapidly diminishes.

Breathing Air Twice.—Now if we breathe air twice over, or if we breathe that which already has carbonic acid in it, derived from some other source, it does not sufficiently change the blood from its black to its scarlet color. It is consequently sent back to the heart, and distributed all over the body, in a state totally unfit for the purposes for which the great Creator designed and gave it; and if this abuse is long permitted, the health suffers.

The air is changed by breathing it, at a most astonishing rate. Probably we inhale—

I speak now of adults, for children inhale proportionally less—about forty hogsheads in twenty-four hours, or more than a gallon a minute.

It is proper to consider air which has been once breathed, as unfit for further respiration, or spoiled. But admitting this to be the case, we spoil the air for the purposes of breathing, at the rate of more than a gallon a minute. So, in fact, Dr. Franklin used to say, fifty years ago.

Ventilation.—Now if these things are so, how careful ought we to be, not to have our rooms in which we sit or sleep too tight, or too long closed. What pains ought we to take to *ventilate* (purify) them often, by opening the doors or the windows. This is the more necessary where we are without fires; for a fire helps to ventilate a room, if there is a chimney; though without the latter, it only renders our condition the more dangerous, since it increases more rapidly the poisonous carbonic acid gas. You have probably read, in the papers, the numerous stories of people

being found dead in rooms which were tight, where they had been burning charcoal.

Our school rooms, our concert rooms, and our churches, too—how dangerous must it be to crowd them, and sit for a long time in them, as we sometimes do, without ventilation. How easy is it to raise a window, or open a door. And though we might thus expose an individual, here and there, to take cold, how much more is he exposed to injury, by sitting in and breathing the bad air.

Free Motion of the Lungs.—Not only should the air be good, but the lungs should have free play in inhaling it. From youth to maturity, we should follow no employment which, for any considerable time, will cramp or confine them. Neither should we sit or stand too long in a bad position, as young people are apt to do, in schools or factories. Nor should our dress be so tight as to press against any part of the chest.

How much is it to be regretted that there are parents, instructors, and even teachers of military schools, who think it proper and ne-

cessary to spoil the lungs, and thus induce disease and shorten life, in order to teach their children, pupils, or cadets, the art of putting back their shoulders and walking erect.

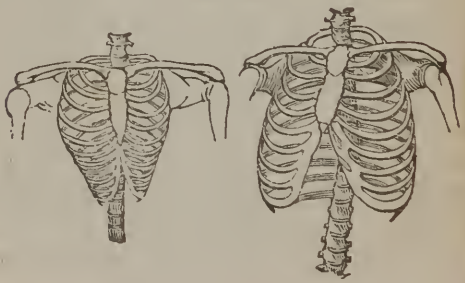
Tight Lacing.—Our health is always injured by all sorts of lacing, as well as by stays, braces, corsets, tight vests, &c. We are not only the more exposed to colds, pleurisies, fevers and consumptions, but also to diseases of the very bones themselves—the breast bone, the ribs and the spine. I say again, therefore, beware of anything tight about the breast. The Prussian physicians recommend to people to wear no cravat or stock, and to leave their bosoms unbuttoned and bare; and no people in the same climate, and under similar circumstances in other respects, are more free from consumptions and all sorts of diseases of the lungs, than those who observe this rule.

It is very strange that so many people—and some too who think themselves very wise teachers—should still hold to the idea that moderately tight lacing of the lungs strengthens them. Mrs. Phelps, in her "Lectures to Young Ladies," inculcates this erroneous idea.

It is greatly to be hoped that the world will very soon get wiser on this subject.

We generally succeed far better in attempts to mend the works of our own hands than those of the Creator. He appears to have made the human frame so perfect, that if in our ignorance, abuse, excess, or vain attempts to improve it, we did not usually injure it, it might last in a healthy condition for a much longer period than it now does.

In closing this chapter, I will show you a picture of the bones of two human chests, one of which is in its perfect state, and the other has been injured by tight lacing. I need not remind you which of them has been injured; its narrow, contracted lower part will at once show you.



I ought also to remark that this picture, according to the statement of Dr. Comstock, by no means exaggerates the evil effects of tight lacing. He says "it is not nearly so great as we believe actually takes place in many instances of tight lacing;" and I believe so too.

If what I have said here on the nature and structure of the chest, should lead any person to study the structure of these important organs, the lungs, from our large but excellent treatises on Anatomy and Physiology, he will find himself most amply repaid for his labor, and will forever bless the day in which his attention was arrested and his mind drawn to the subject.

CHAPTER XVII.

TEMPERATURE OF APARTMENTS.

Curious Question. Variations of Temperature.

Few if any ordinary buildings, whether dwellings, shops, or factories, are so constructed as to preserve exactly the same temperature in every apartment and at all seasons. And as for heating *themselves* in this manner, by the very employments or manufactures which are carried on within them, nobody probably ever heard of such a thing. A self-heating house! Why it would excite as much astonishment as would a machine which should really have the power of perpetual motion.

And yet the house I live in has this power, wonderful as it is, of not only heating itself by the process of generating and purifying blood, of which I have treated at a great length, and by others curious processes, but of regulating

that heat, and keeping it at just such a point, with scarcely any perceivable variation.

The heat of the human body is never far from 98° of Fahrenheit's thermometer. By this we mean, that if you could plunge the bulb of the thermometer, containing the quick-silver or mercury, into the flesh of the body, or even hold it in your mouth, the mercury would rise in the tube till it got to about 98°, and then stop.

Now why does this heat continue nearly the same at all times, and in all places? If you were to take a piece of wood or iron, about the size and shape of a man, heated to 98°, and set it up in Greenland or Lapland, where it is so cold that the mercury would sink to 20° in the open air, do you think this iron would remain heated to 98°? Would not the air cool it down to about 20°? How would it be with a man of wood or straw? How, even with the body of a *dead* man?

Does any one suppose that the body of a *dead* man heated about as hot as that of a living man, and put out in the open air of Greenland, would remain so warm very long? Then why

should the *living* body of a man? Why does not the cold air rob it of its spare heat, just as it would a mass of straw or iron? Yet nothing is better proved than that it does not.

The skin, and outside of the hands, face, &c., may be cold, and sometimes *frozen*, but the blood and flesh will generally remain about as warm as ever, unless a person actually *freezes to death*. In that case, the heat escapes very soon; and hence the dead, as you know, soon become cold.

Curious Question.—But why the heat does not escape from everybody, so that they freeze to death, is the point in question. You will not suppose there is a fire somewhere in the inside of us, which keeps up the heat. For if so, what supplies the fuel? Did you ever know of any wood or coal being used for the purpose? *Spirits* will burn, it is true, but some people do not pour any of this into their bodies to make fire of, and yet they are just as warm as other people; nay, even warmer; for the blood of the dram drinker is a *little* colder than the blood of the man who drinks nothing but water.

When we think of all this, and remember that people can live very comfortably in climates like Labrador, and Greenland, and Norway, and Lapland, and Siberia, where everything around them—air, water, earth, trees, &c.,—is cooled down to less than half the heat of the human body, for almost all the year, and to the freezing point, (32° of the thermometer,) a part of the time, is it not a great wonder that all our bones, and flesh, and blood, can keep up to a temperature of 98°, or nearly that, not only through an hour, or a day, but through a pretty long life?

It is, indeed, almost a miracle; or would be thought so, if we thought anything about it. It shows at least, how wonderful *life* is. For not only *man*, but *all* living animals have this same power. Birds have even a higher heat than man. The blood of some of them rises to a temperature of about 108°. If it were not so, they would often freeze to death in the cold season, and perhaps split to pieces; as the frost, in swelling it, sometimes cracks the frozen ground to pieces, and as trees are sometimes split in the same way, in very severe winters.

You should be told, also, that living trees, and shrubs, and plants, and seeds, have this same power of resisting the cold—*in a degree* —that animals have. Trees do not often freeze very hard. Were it not for this contrivance of the great Creator, everything would perish in the winter; and we should have no beautiful trees and green fields in the spring. Besides, if we had, there would be no men and other animals alive to enjoy them.

But we not only have this wonderful power of resisting cold; we are also equally able to resist extreme heat. By long practice, men have become able to remain in ovens and other places, heated to 220°, and even 270° of Fahrenheit, for ten or twelve minutes at a time. The only serious inconvenience which arises in such cases is a profuse perspiration.* But a piece of flesh without life would, in ten min-

* Perspiration always modifies the heat of the human body more or less, and is one means of keeping us cool. The reason is, that the moisture on the surface of our bodies evaporates; and this produces cold. It is said that you may almost freeze a man in midsummer, by keeping him wet with ether; so rapidly does the ether evaporate.

utes, in such a heat, be thoroughly baked. Water boils, as you know, at 212°.

Having laid down and illustrated the general rule that the temperature of our bodies does not vary much, it may be well to mention some of those slight variations which, in different circumstances, are found to exist.

VARIATIONS OF TEMPERATURE.—Infants, except when just born, have a temperature of only about 94°. The heat increases to maturity, after which it remains nearly stationary at about 98°, until we begin to decline, when it again slightly diminishes. In the spring and the beginning of summer, it increases a little, in persons of every age; but declines again towards winter. When a person is greatly enfeebled by sickness or otherwise, it is slightly diminished. In fevers and inflammations, it sometimes increases to 104°, and even to 107°.

But I have not yet told you *how* this steady temperature of 98° is kept up in the human system, in spite of the extremes of heat and cold. Indeed I cannot do it; for I do not know. I have already told you that the evaporation of the matter of perspiration on our

skins has some effect in keeping us cool; but this cannot be the sole cause why men can remain with impunity in places heated to a greater temperature than boiling heat. There must be other causes not yet fully understood.

As to the reason why we retain so high a heat as 98°, when the temperature of the atmosphere is almost always greatly below that, there have been a great many speculations—guesses—by philosophers; but they have, in general, been *mere* guesses. The process of digestion, the formation of chyle, the change of chyle into blood, and the change of the blood in the lungs—especially the latter—are all believed to have a part in the work. Yet they do not, by their united efforts, accomplish one half of it; and it remains for future anatomists and physiologists to investigate the subject more deeply. How far the laws of the great Creator may ultimately be discovered, in this, as well as in a thousand other things, of which we are yet ignorant, it is not easy for us, in the present infancy of human knowledge, to conjecture.

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